# A LABORATORY MANUAL OF PHYSICAL GEOGRAPHY

TARR AND VON ENGELN

THE MACMILLAN COMPANY

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THE MACMILLAN COMPANY
NEW YORK · BOSTON · CHICAGO
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LONDON · BOMBAY · CALCUTTA
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THE MACMILLAN CO. OF CANADA, LTD.
TORONTO

# A LABORATORY MANUAL

OF

# PHYSICAL GEOGRAPHY

BY

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AT CORNELL UNIVERSITY

FOR USE IN CONNECTION WITH A GENERAL COURSE IN PHYSICAL GEOGRAPHY IN HIGH AND SECONDARY SCHOOLS AND IN COLLEGES



New York
THE MACMILLAN COMPANY
1910

Set up and electrotyped. Published March, 1910.

Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.

# PREFACE

The subject of physical geography, above all others, leads to an appreciation by the pupil of the natural world in which he lives, and an introductory course in physical geography should include specifically a training in observation and deduction.

In the planning and writing of this manual these fundamental concepts of the necessity of making the outlines at once practical and usable for the teacher with only a limited laboratory equipment, and at the same time offering to the pupil this training in observation and deduction — in fact, compelling it — have been constantly kept in mind, and it will be found that there is a specific purpose for each exercise and that the groups form coherent wholes. It is the belief of the authors, moreover, that the exercises cover the whole subject adequately, and that the order in which they are arranged will be found the best for presenting the subject. On both these points some teachers, for specific reasons, may take issue. This, however, implies no criticism, either on the manual as arranged or on the teacher; for, on the one hand, the loose-leaf construction of the manual makes it a very simple matter for the teacher to change the order or introduce other work; while on the other hand, the authors feel that teachers who are progressive, capable, and enthusiastic over the subject should be given the greatest latitude in carrying out their own ideas. The laboratory study of physical geography has an intense human interest and affords the best possible opportunity for the infusion of a strong teaching personality.

A number of novel ideas and methods have been incorporated in this manual, but these new features are not to be regarded as experiments. The senior author has had over fifteen years' experience and the junior author four in the laboratory teaching of physical geography, and the make-up of this manual incorporates plans that have been successfully used with classes after repeated changes and modifications to secure the best possible results.

The feature which will first attract attention is the leaving of space after each question for the student to write the answer. This serves a double purpose. It insures the student's following the argument of the outline and the appreciation of every point by personal observation and deduction. The work thus becomes distinctly laboratory work and not essay writing under the delusion that laboratory work is being done. This latter condition is the greatest fault that the authors have found in most of the laboratory note-books, from various schools throughout the country, which have come under their inspection. In the second place this plan very materially lightens the labor of the overworked science teacher in inspecting the note-books of the students. There is a place for every answer and every answer should be in its place. Any incompleteness is readily detected, as is also the correctness of the student's interpretations. Furthermore, the time of the student is conserved for the actual observations, inasmuch as there is no need for the laborious rewriting of questions in order to make the disconnected answers coherent. There is, however, sufficient space allowed after every exercise to permit of the insertion of other material presented by the teacher; accordingly, the exercises may vary considerably in different localities to insure a fuller understanding of local conditions.

Another feature which we feel sure will meet with general approval is the insertion of all maps, figures, diagrams, and tables at the exact place where they are needed. The convenience of this plan will make its own appeal, and needs no further amplification here.

The pedagogical departure in which this manual differs most markedly from those now in use, and which is an altogether novel feature of these outlines, is the method of presenting the physiography of the lands. In the past, in the authors' own experience and as related by other teachers, the map work on which this phase of the subject is necessarily based has been most distasteful and irksome to the student. This, we believe, is due to two causes: (1) the incoherent manner in which the various topics have customarily been treated; and (2) the fact that these topics have never been tied on to any geography of which the student had a previous knowledge. To illustrate what is meant, take the subject of the development of river valleys. In the first place the student was taught that Niagara River had a young valley, and he studied its characteristics. The Mississippi, perhaps, was next studied as an old valley. Then there was a jump to the study of a volcanic cone, Mt. Shasta. Nowhere any logical development of the body of the subject-matter, nor any relation between succeeding exercises.

This difficulty we believe we have successfully solved. In this manual young rivers are studied in connection with young plains, old rivers on old plains, and plains in turn are considered in successive stages in their cycle of development from young to old. The basis of the whole study is a series of carefully selected United States Geological Survey topographic maps, and the position of these areas the student accurately locates on a United States map, on which, also, he plots that physiographic division of the country which has conditions similar to those shown in detail on the topographic map he is studying.

The results in our own classes have been very gratifying. The students pursue the work with keen interest; they gain a very clear notion of the physical geography phenomena which the maps illustrate; moreover, they associate the typical conditions of the topographic maps with distinct areas and regions of the United States and thus gain a clear comprehension of the varied topographic features of their own country and of their extent and significance. This supplies the element of *human interest* which has been so lacking in elementary physical geography study in the past; and it is largely to this fact that the eager interest of the students in the above plan of study may best be ascribed.

The sections dealing with mathematical geography and tidal phenomena have been made very simple. These are complex subjects at best, and it is the belief of the authors that they are of a distinctly minor importance in a course in elementary physical geography.

Emphasis should be placed on the study of the processes of erosion, transportation, and deposition as made possible by the use of the tank and land model, or some modification of it. Such work is of the greatest value in enabling the students to get a clear, clean-cut concept of these processes and their results; and it enables them to proceed intelligently with the study of the topographic forms shown on relief maps.

A few type excursions are included, four for the fall and three for the spring. It is, of course, not possible to write excursion outlines in detail that are suitable for widely different localities; hence these excursions are generalized. It is the hope and belief of the authors that they will be found useful in many schools; but it is confidently expected that for some or all of these many teachers will substitute specific outlines adapted to the opportunities of the locality.

It is our belief that if a multitude of references are given, none will be used. Therefore we have confined ourselves in the outlines to references to Tarr's "New Physical Geography." Here may be added the titles of several publications which the teacher will find valuable for reference: Professional Paper #60, United States Geological Survey. List of the Publications of the United States Geological Survey. These may be obtained, gratis, on application to the Director of the United States Geological Survey, Washington, D.C. In the list of publications the teacher will find what has been published on the home locality, and should send for such papers as are available. Other valuable helps are: —

Johnson, Mathematical Geography, American Book Co.

Pirsson, Rocks and Rock Minerals, Wiley & Sons.

Davis, Elementary Meteorology, Ginn & Co.

Ward, Practical Exercises in Elementary Meteorology, Ginn & Co.

Other text-books of physical geography.

Many valuable papers on methods in physical geography are printed in the *Journal of Geography* (R. E. Dodge, Teachers College, Columbia University, New York City), a monthly magazine "Devoted to the Interests of Teachers of Geography." Price, $1.00 a year.

The authors will welcome any suggestions teachers may make, and, where practicable, insert them in future editions.

ITHACA, June 10, 1909.

# SUGGESTIONS TO TEACHERS

A TEACHER'S manual for use in connection with these outlines for laboratory and excursion work is in preparation and will be issued shortly. In it will be found particular suggestions in regard to each exercise, together with a list of references for supplementary reading and hints on the use of lantern slides, models, and other material which may be available in connection with these outlines.

In the following paragraphs are given a description and suggestions for the use of the apparatus needed in Exercises XXII, XXIII, and XXVI. These are inserted because this method of presentation of the subject is new, and most teachers will be unfamiliar with the apparatus used.

## EXERCISES XXII AND XXIII

### *The Construction and Understanding of Contour Maps*

On a thorough understanding and appreciation of the significance of contour lines depends the value of all the pupil's later study of topographic conditions as expressed by maps on which they are used. The simplest method of teaching the meaning of contour maps, where there are no laboratory facilities, is for the teacher to draw on the blackboard an outline of a land surface and on it write in figures indicating elevations of different points and having the pupils copy this and connect points of equal elevation with contour lines. This and similar methods we have found very unsatisfactory. The apparatus and method advised and outlined in this manual are those used with much success at Cornell University, where they solved this problem of teaching contour maps after various other methods had been tried with indifferent results. The apparatus is subject to several modifications. Where space and funds are available, it will be found well worth while to install a large tank with a crank-lifted platform as described below. This apparatus can also be used for study of erosion and depositional processes. (See following pages devoted to such exercises.) If the dimensions given are too large, they can readily be scaled down to meet the space conditions of the laboratory where the apparatus is to be installed. The working drawings will make the construction of the apparatus feasible in any locality, or the Geography Supply Bureau, Ithaca, New York, will quote prices on duplications of various sizes.

### *Description of Large Tank and Screw-crank Platform*

A large square wooden tank, made water tight, eight feet on the side and sixteen inches deep. This tank is used to hold a body of standing water whose level may be adjusted, to suit the requirements of the exercise, by means of a series of holes (bored in the side) fitted with removable plugs.

A solidly built square platform five feet six inches on the side. This is intended to hold the sand, clay, or other materials of which a land form is to be molded.

In the four corners of this platform threaded iron collars are inserted, and into these are screwed heavy iron cranks which serve at once to support the platform and raise and lower it. The threads on the cranks and in the collars are coarse, some ten or twelve turns to the inch. The ends of the cranks are pivoted in loosely fitting iron sockets screwed fast to the bottom of the outer tank.

When this apparatus is set up, the whole platform, with its incumbent model, can be rapidly raised and lowered at will, by turning the cranks simultaneously.

The materials used in building up the model are sand and clay, with enough plaster of paris admixed (a very small quantity serves this purpose) to give the forms sufficient firmness to stand up without slumping when immersed in water for some time. Just before the beginning of the exercise the outer tank is filled with water, the water level being adjusted by means of the plugs on the one side, and the platform is lifted by means of the cranks until the water surface coincides with the level of the lowest parts of the land surface.

The drawing shows the apparatus adjusted with land form modeled ready for the class to begin work. The square outline of the map to be constructed will then be expressed by the square outline of the platform top. Working drawings of the apparatus are given in the accompanying drawing.

### *Conduction of Exercise*

To conduct the contour mapping exercise proceed as follows: After a suitable scale for the map has been adopted, outline of the model sketched, and its salient points located, the pupils have made a map on which the 0 or sea-level contour is expressed by the outline of the land form. Then a contour interval is adopted. (A one-inch interval will be found practicable for this size model.) Next, with a pupil to operate each crank, lower the model through the vertical distance of the contour interval. Be sure that the outflow of the tank is sufficiently large to allow the water displaced to escape rapidly. Then the class proceeds with the sketching of the first contour. This procedure is repeated as many times as necessary to complete the map.

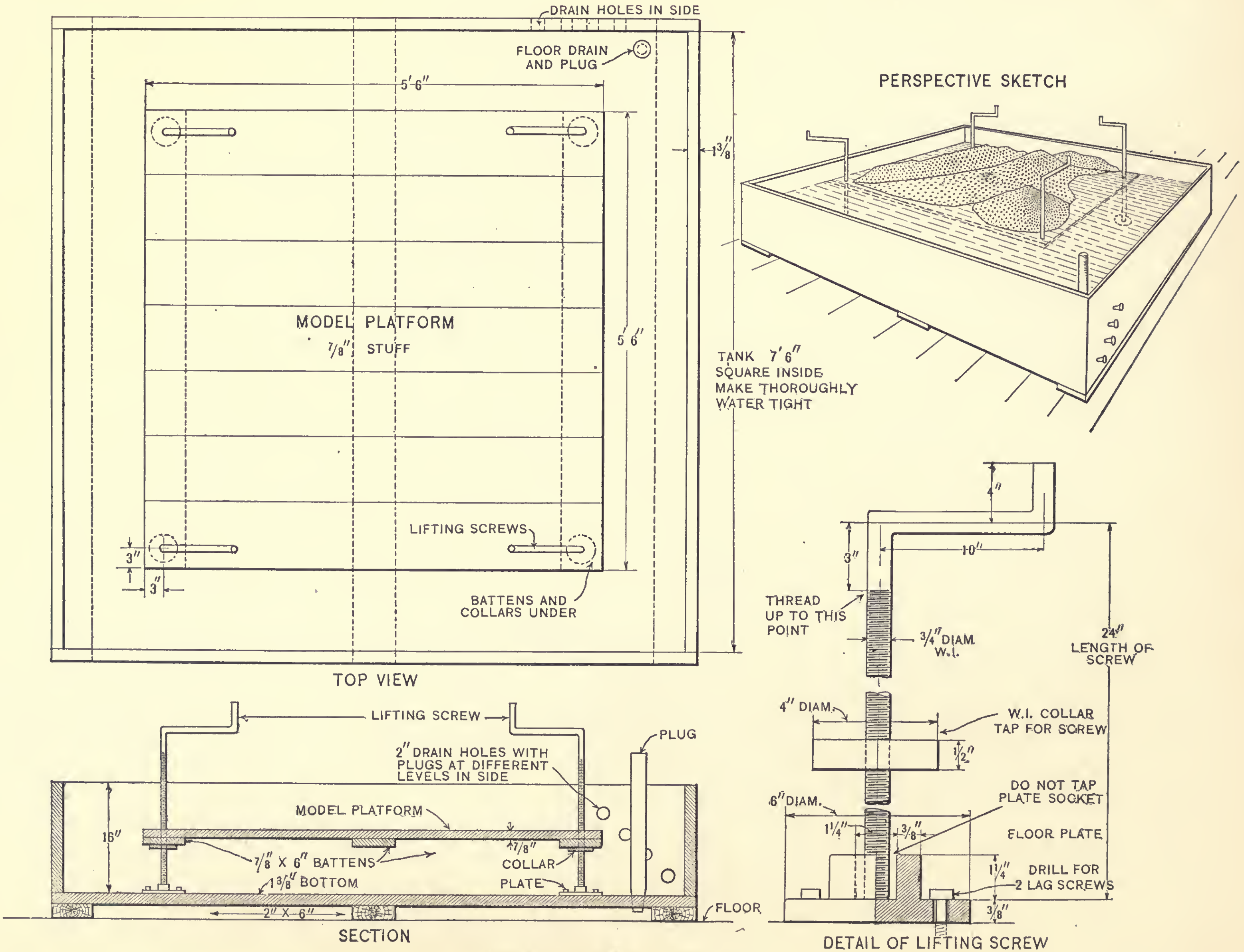
Where the installation of the large screw-tank apparatus is not feasible the following modification may be used. This serves fairly well with small classes.

Instead of the platform with screw cranks and land form modeled of clay and sand a much smaller plaster of paris model is used. This is a model after an ideal land form which the United States Geological Survey uses in describing contour maps. (See one of the United States Geological Survey Folios.) In connection with it a small tank of water is used, filled to the brim. In this tank are piled a number of waterproof fiber boards of uniform thickness and heavier than water. The plaster model is placed on this pile of fiber boards and the water level adjusted to the edge of the modeled land area. Successive contour lines are located by removing successive sheets of the fiber board. Otherwise the procedure is the same. This equipment is also simple of construction, but if preferred, can be obtained through the Geography Supply Bureau of Ithaca, New York.

## EXERCISE XXVI

If the tank and land model are not available, a sand table or sink of sufficient dimensions can be arranged to carry out this experiment.

In building up the land form use molder's sand and powdered clay in alternate layers. Have the clay layers quite thin, one half inch on the average. Build the model so that it has variety in topography, but give it the general surface of a plain with a somewhat steep slope toward the front. It will be well to incline the platform. If the clay layers are not sufficiently hard to cause waterfalls, a little plaster of paris may be added. To get good deltas the water at the edge of the land form must not be too deep, and must remain at a uniform level. The pupils should read through the whole exercise before the experiment is begun so that they will be on the alert for the various phenomena. (For further details see article by Tarr and von Engeln, in *Journal of Geography*, Vol. VII, 1908, pp. 73–85.)




Tank and Land Model Apparatus.

# COMPLETE LIST OF MATERIALS NECESSARY FOR USE IN CONNECTION WITH THESE OUTLINES

(Some of these may be omitted according to the discretion of the teacher.)

### For Each Student

(a) *Material which the student can bring to the classroom from home at different times.*

Apple, knitting needle, string, pencil, ruler, plain paper, watch (where possible), small bag or basket, steel knife or scratch point, window-glass fragment, drinking glass, piece of candle, several small pieces of cheese cloth, several needles, coal fragment, baseball.

(b) *Material which student may purchase.*

Box of colored pencils (six different), cost 10 cents. Map of the United States $18 \times 28$ inches with contours, published by United States Geological Survey. Should be mounted on cloth. Cost 10 cents.

(c) *Material to be furnished by the school.*

Small desk globe, simple compass dividers, several glass plates $4 \times 4$ inches approximately. Copy of weather map, any date. Bar magnet. Several test tubes. Mineral and rock fragments, unlabeled, following varieties: quartz crystal, orthoclase and plagioclase feldspar, hornblende, halite, biotite and muscovite mica, calcite, gypsum, iron pyrites, dolomite, hematite, magnetite, granite, sandstone, fossiliferous limestone, schist, pumice, cellular lava, obsidian, rhyolite, trachyte, syenite, gabbro, basalt, conglomerate, shale, gneiss, quartzite, slate, marble, rock with lichen attached, rounded stream pebbles, residual soil from granite, residual clay from limestone.

United States Geological Survey topographic sheets (should be mounted on cloth) as follows: —

Montross, Maryland–Virginia.
Fargo, North Dakota–Minnesota.
Donaldsonville, Louisiana.
Winterville, North Carolina.
Mt. Carrizo, Colorado.
Syracuse, Kansas.
Kearney, Nebraska.
Centerpoint, West Virginia.
Caldwell, Kansas.
Whitewater, Wisconsin.
Weedsport, New York.
Niagara Falls and Vicinity, 1901, New York.
Cleveland and Vicinity, Ohio.
St. Louis, Missouri.
Denver, Colorado.
Monterey, Virginia–West Virginia.
Delaware Water Gap, Pennsylvania–New Jersey.
Mt. Mitchell, North Carolina–Tennessee.
Farmville, Virginia.
Lake Placid, New York.
Saw Tooth, Idaho.
Chief Mountain, Montana.
Spokane, Washington–Idaho.
Granite Range, Nevada.
Bright Angel, Arizona.
Yosemite California Quadrangle.
Map of Yosemite Valley, California.
Shasta, California.
Shasta Special, California.
Cucamonga, California.
San Francisco, California.
Tamalpais, California.
Boothbay, Maine.
Barnegat, New Jersey.
Port Orford, Oregon.
Van Horn, Texas.
Crater Lake Special, Oregon.
Map of Home Region, if published.

(a) *Material of which the teacher may secure the use without cost.*

An egg, saucer, bottle, pebbles, shears, field soil from beneath sod, fruit jar, piece of muslin, daily weather map.

(b) *Material to be furnished by school.* (Note. — Much of this material can probably be borrowed from the physics and chemistry laboratories of the school.)

Several wall maps of different scale.

Wall map of the United States, showing railway lines.

Chart # 14 of the Mississippi River Commission.

Land model tank (see Suggestions to Teachers).

Several yardsticks.

Spray nozzle and rubber hose.

Several magnetic compasses.

Air pump.

Glass tube 35 inches long, closed at one end.

Bottle of mercury.

Funnel.

Mercury barometer.

Several thermometers.

Bottle of alcohol or ether.

Simple rain gauge.

Several sheets of wrapping paper.

Wooden rod.

Sheet of white cardboard.

Several hammers (geological, if possible).

Dilute hydrochloric acid.

Several glass stirring rods or dropping bottles.

Labeled hand specimens of the minerals and rocks listed on preceding page.

(c) *Supplemental. Material which may be used if available.*

Meteorological instruments.

Hand specimens of iron, gold, silver, copper, lead, and zinc ores.

Lantern slides for quizzes.

Note. — If teachers find difficulty in securing any of these materials, it is suggested that they apply to the Geography Supply Bureau, Ithaca, New York.

**Cross-section paper needed will be found at the end of the manual.**

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# THE EARTH AS A WHOLE

## I. — SHAPE AND SIZE OF THE EARTH

**Materials.** **For Each Student. — Desk globe. Apple. Knitting needle. String. Pencil. Ruler.**

**Purpose.** *To gain an appreciation of the form of the earth and its dimensions.*

**A sphere defined.** Give a definition of a sphere in as few words as possible. ____________________________

____________________________________________________________

____________________________________________________________

Name three objects that are spheres. ____________________________________________

**The earth an oblate spheroid.** Is an apple a perfect sphere? ________________ How do most apples differ from a true sphere? ____________________________________________________

What is the name given a spherical body that is flattened at the poles? __________________

______________________________ Make a sketch to show how an oblate spheroid differs from a true sphere.

How much is the earth flattened at the poles? ______________________________

Why are globes always made as true spheres, though the earth is an oblate spheroid?

____________________________________________________________

____________________________________________________________

**Meaning of diameter and circumference.** What is meant by the diameter of a sphere? ____________________________

____________________________________________________________

____________________________________________________________

Thrust the knitting needle through the center of the apple, and with a ruler measure the diameter of the apple. ________________ What is meant by circumference ?

________________________________________

________________________________________

With the string and ruler measure the circumference of the apple. ________________

How many times greater than the diameter is the circumference ? ________________

________________ The circumference of a sphere is always that much greater than the diameter. Since the diameter of the earth is a little over 7900 miles, how many miles is the circumference ? ________________

**Meaning of axis and equator.** Thrust the knitting needle through the center of the apple from the stem end; then, resting one end of the needle on the desk, turn the needle so that the apple turns with it. The needle is the axis on which the apple rotates. What terms would you apply to the two ends of the axis ? ________________ What does this experiment illustrate with regard to the earth ? ________________

________________________________________

________________________________________

What is the circumference of the earth midway between the poles called ? ________________

________________ Mark the equator on the apple. Make a drawing of a sphere, shading it so that it appears round. On it mark the equator and the poles.

## II. — PROOFS THAT THE EARTH IS A SPHERE

Materials. **For Each Student. — Desk globe. Pencil.**

**For General Class Use. — An egg. Saucer. Bottle. Pebbles. Book.**

Purpose. *To show, by simple proofs, that the earth has a spherical form.*

**By journeys around the earth.**

What did people believe the shape of the earth to be when Columbus started on his first voyage? ____________________________________________

____________________________________________

What did he believe? ____________________________________________

What expedition was the first to make the voyage completely around the earth and return to its starting place? ____________________________________________

Push your finger around the globe from east to west; from north to south; in other directions. In each case, if you follow a straight course, do you come back to the point where you started? ______________ Would that be possible if the earth were flat? ______________ This proves that the earth is a curved body. But does it prove it to be a sphere? ______________ Could you do the same thing on a body shaped like an egg? ______________ It is a longer distance around an egg in some directions than in others. Is this true of a sphere? __________ Is it true of the globe? ____________

**By means of eclipses of the moon.**

Examine your desk globe to see that every part of its surface is curved. Place it in the sunlight so that its shadow will fall on the floor. What is the outline of the shadow? ______________________________ Turn the globe in various positions. Does the shadow change in form? ______________ Try the same experiment with several objects, such as a bottle, a pebble, a saucer, an egg. What is the result? ______________________

____________________________________________

____________________________________________

____________________________________________

Does any other object than a sphere *always* cast a circular shadow? ____________________

Sometimes the earth's shadow is cast on the moon, when the earth comes between the sun and moon. This is called an *eclipse*. Have you ever seen an eclipse of the moon? _____________

Describe it. ____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

The shadow of the earth is always round in such an eclipse. What does that prove?

____________________________________________________________

**By gradual disappearance of objects in the distance.**

Place an object on the flat surface of your desk. When your eye is above the level of the desk top, can you see this object from all points of view? _______________ Is the same true of an object placed on the curved surface of a globe? _______________ Stick a pin in the globe and turn the globe. As it turns away from you the pin slowly disappears from view. Which end of the pin disappears first? ________________________________________

Where are the most level places on the earth? ________________________________________

________________________________________ What part of a ship at sea is first seen as it comes toward you? ________________________________________ Make a drawing to show this. (See Fig. 6, Text-book.) Then make a drawing to show what would be the case if the earth were flat.

Objects disappear on the curved earth at a regular rate, no matter in which direction one looks. This rate is 8 inches the first mile, 32 inches the second mile, and so on. The rate is the square of the number of miles times 8 inches. How much will the disappearance be at the third mile? ($3 \times 3 = 9 \times 8 = 72$ inches.) How much at the fourth? ________________

________________________________________ The fifth?

________________________________________

Would it be true that an object would disappear at a regular rate in all directions and in all places on a cylinder? ______________ On an egg? ______________ On any other than a spherical body? ________________ What then do you conclude in regard to the form of the earth? ________________________________________

**By position of the stars.**

Heavenly bodies also change position at a regular rate when viewed from different points on the earth. At the equator the north star is on the northern horizon, no matter at what part of the equator one stands. At the north pole it is overhead. Where would it be half-way between pole and equator? ________________________________ Could this be true if the earth were egg shaped? ______________ Or pear shaped? ______________ Or cylinder shaped? ________________

**Other spheres in the heavens.**

Name other spherical bodies in the heavens. ________________________________________

________________________________ What would be the appearance of the earth if it could be seen from the moon? ________________________________________

Make a drawing to scale (below) to show the comparative size of the earth and moon. (Text-book, p. 1.) Of the earth and sun. (Text-book, p. 3.)

What is an eclipse of the sun? ________________________________________

________________________________________

How does this prove that the moon is a sphere? ________________________________________

________________________________________

## III. — WORLD MAPS

**Materials.** **For Each Student. — Pencil (sharp). Ruler. Small desk globe. Several sheets of blank paper.**

**For General Class Use. — Maps of different scale. Pair of shears. Several baseballs. Sheet of wrapping paper.**

**Purpose.** *To teach the meaning of scale, and to show the difficulty of representing the curved earth's surface on a flat map.*

**Meaning of scale.** What is the greatest distance that you can see in any one direction in your locality? (Express in city blocks or miles.) ______________________________

______________________________ If you wished to represent five miles, or five city blocks, on a piece of paper the width of this note book, what would you need to do?

______________________________

______________________________

As applied to maps, what is the term used to express this scheme? ______________________________

______________________________

Draw below a distance of 6 miles expressed by a scale of $\frac{3}{4}$ inch = 1 mile.

How must the scale of a map vary with the size of the area represented? ______________________________

______________________________

______________________________

If a map of an area 5 miles square, and one of an area 1000 miles square were both of the *same* size, which would show more detail? ______________________________

______________________________ Could a road 25 feet wide be accurately located by double lines on a map drawn to the scale 1 inch = 1 mile? (Make the calculation on a separate sheet of paper and copy the calculations and your conclusion below.)

______________________________

______________________________

______________________________

______________________________

Examine different maps, as directed by the teacher, and note in the space below the areas they represent and what scales are used.

| Name of Map | Scale Used | Area represented in Square Miles (to be determined by Use of the Scale) |
| --- | --- | --- |
| ------------------- | -------------------------- | ---------------------------------- |
| ------------------- | -------------------------- | ---------------------------------- |
| ------------------- | -------------------------- | ---------------------------------- |
| ------------------- | -------------------------- | ---------------------------------- |

Explain the significance of the fraction (such as $\frac{1}{62,500}$) used on maps in connection with the scale. ------------------------------------------------------------------------

------------------------------------------------------------------------

------------------------------------------------------------------------

**Globes.**

What form would give the most accurate representation, in miniature, of the whole world?

------------------------------------------ What are some of the disadvantages of a globe map; for instance, for use in books? ------------------------------

------------------------------------------------------------------------

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**Plane surface maps.**

Try to fit a sheet of paper over one half or more of your desk globe. What is the result?

------------------------------------------------------------------------

------------------------------------------ Examine a baseball. How many parts are there to its cover? --------------- What proportion of the ball's surface does each part of the cover fit over? ----------------------- Draw an outline of one of these parts.

Why was such a shape adopted for baseball covers? ______________________________________

____________________________________________________________________________

______________________________________________ Cut a piece of paper of the same shape, and large enough to use in covering one half of your desk globe. Apply it to your globe in different positions. What parts of what continents can you cover in different positions?

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

What great objection to making world maps of this shape does this experiment disclose?

____________________________________________________________________________

____________________________________________________________________________

Examine Figs. 28, 444, and 515 in Text-book to see the shape of some of the maps used to represent the earth on a flat surface. What is the result of your observations? ___________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

## IV. — MAP CONSTRUCTION

**Materials.** **For Each Student. — Pencil. Ruler. Desk globe. Dividers.**

**For General Class Use. — Several wall maps.**

**Purpose.** *To gain an understanding of the essential features of a map, methods of map projection, and their application.*

**Meaning of latitude and longitude.** In ancient times the land of the world was thought to be longer in an east and west direction than in the north and south direction. Figure 1 is a copy of an early map of the world, as devised by Ptolemy. In what years did he live? ______________________________________


FIG. 1. — PTOLEMY'S MAP OF THE WORLD.

Latin was then the language of the Mediterranean region. What is the meaning of the Latin word *longus?* ______________________ Of the Latin word *latus?* ______________________

Which lines on Ptolemy's map are used to mark off the *long directions?* ______________ ______________________________________________________________________ Which lines to mark off the width? ______________________________________________________

______ Why were the lines running north and south called lines of longitude?

______

______ Why were those running east and west called lines of latitude? ______

______ Where did Ptolemy start numbering the lines of latitude? ______

______

The lines of longitude? ______

What latitude would one have *north* of a zero point? ______

What latitude *south* of a zero point? ______

What is the zero line of latitude on your globe? ______
Do you know of any similar natural line which could be used for a zero line of longitude?

______ Through what city does the zero line of longitude on your globe pass? ______ Might not Paris or Washington be used?

______ Why, then, does the zero line for reckoning longitude often vary with the country where the map is made? ______

______

Consult several maps and state which line is most commonly used. ______

______ Where is Greenwich? ______

**Latitude and longitude on the globe.**

Trace several lines of latitude around the globe? Why are these circles called "parallels of latitude"? ______

Trace in the same manner several lines of longitude. Are they parallel? ______

At what two points do they meet? ______
The longitude lines are called *meridians* of longitude.

If you have studied geometry, prove that two straight lines can intersect at only one point.

After examining your globe again, will you agree that with the exception of the poles this proof also applies to the intersection of the parallels of latitude and the meridians of longitude? ________________ Bearing this in mind, can any one point on the earth's surface (except the north and south poles) have more than one latitude and one longitude? ________________ On your desk globe locate the city which has (nearly) 60° North Latitude and 30° East Longitude from Greenwich. ________________ What is the longitude of this city, starting from Washington as the prime meridian 0°? ________________ Determine from your desk globe the latitude and longitude (Greenwich meridian) of your home region. ________________ My home, ________________, is at ________________ latitude and at ________________ longitude ________________ of Greenwich. How can the exact location, north or south of the equator, of any point on the earth's surface be stated? ________________ Its distance east or west of any given meridian? ________________

________________

How many degrees are there in the circumference of a circle? ________________ In a half circumference? ________________ A quarter circumference? ________________ How many degrees of north latitude can there be? ________________ East or west longitude? ________________

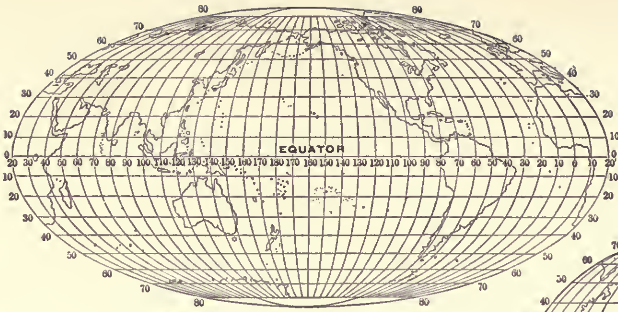
Assuming that the earth's circumference is 25,000 miles, what is the length, in miles, of a degree of longitude at the equator? ________________ At the poles? ________________ At 60° N. or S. latitude? (Use dividers for measuring on the globe.) ________________ How do the distances between meridians vary on your globe? ________________

________________

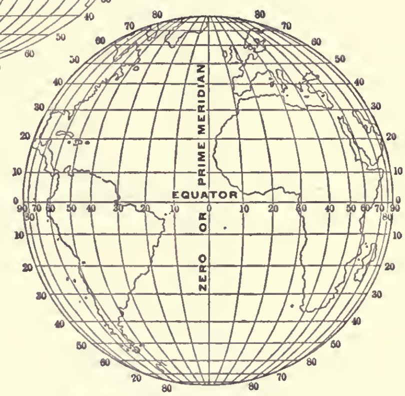
**Plane surface mapping.**

Map makers have devised many schemes to overcome the difficulties of mapping a curved surface on a plane surface. These schemes are called *projections.* Some of these are the Orthographic, Stereographic, Globular, Gnomonic, Homolographic, Conic, Polyconic, Van der Grinten, and Mercator's Cylindrical projections. (See Fig. 2.) How do some of these differ in the manner of representing meridians and parallels of latitude? ________________

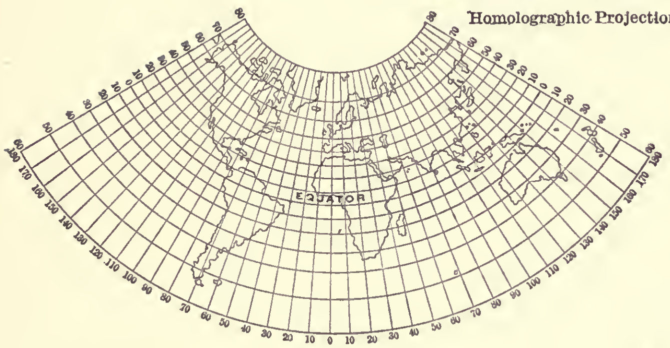
________________



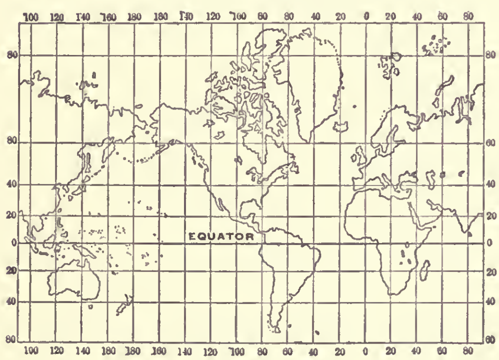

Homolographic Projection



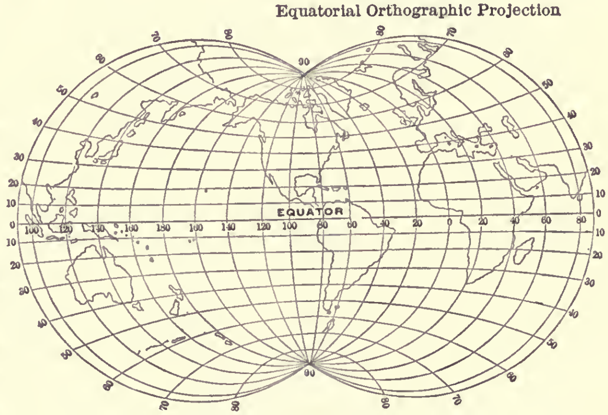

Equatorial Orthographic Projection



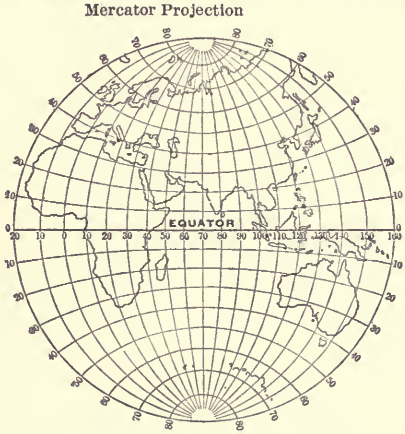

Conic Projection




Mercator Projection




Van der Grinten Projection




Equatorial Stereographic Projection


Western Hemisphere
in Equatorial Globular Projection

FIG. 2. — VARIOUS PROJECTIONS.

Why are maps and charts of greater importance to sailors than to any other class of people?

Remembering that sailors have instruments for determining latitude and longitude, consider and state your reasons in answering the following: Which is of more importance to sailors — to have *distances* between points shown *truly* on a map, or to have *directions* between points shown as *straight* lines?

(The Mercator projection was invented by a German whose name was Kramer. In German this word means "retail merchant." The Latin for merchant is *mercator,* and thus the projection got its name.)

The Mercator projection was designed to show all parallels and meridians as straight lines at proportional distances; hence, *directions as straight lines.* Thus the sailor has simply to draw upon the map a straight line from the point where he is to the point to which he wishes to sail, in a straight course. He can then steer his ship according to the bearings thus obtained.

## V. — THE MERCATOR MAP

**Materials.** **For Each Student. — Dividers. Sharp pencil. Ruler. Desk globe.**

**Purpose.** *The construction of a Mercator map; and to get an appreciation of the distortion involved in such a map.*

**Constructing a map on Mercator's Projection.** Figure 3 is a beginning of a Mercator Cylindrical Projection. The circle represents a north and south section of the globe. The diameter of the circle shows 180° of the equator as a straight line, and this line is continued into the map diagram that adjoins the circle. From the center of the circle angles are laid off for every 15° north of the equator. The line *A–L*, representing the western edge of the map, is perpendicular to the equator line. The *length* of the line *parallel* to *A–L* (that is, *Bx*), and *extending* from the *end* (*B*) of the *first radius* north of the equator, gives the *distance* that the 15° *parallel of latitude* of the map is to be drawn *north* of the equator line. (The 15° parallel, as drawn, is marked *C–D* on the diagram.) In the same way the length of the line parallel again to *A–L*, and extending from the end of the radius of 30° *to the 15° radius*, gives the distance that the parallel of 30° north latitude is to be drawn above that of 15° north latitude. (This, the 30° line, is marked *E–F*.) Follow this procedure and complete the drawing of the parallels for both north and south latitude up to 75°.

Draw the meridians of longitude at equal distances from each other, and the same distance apart as the first parallel of latitude is from the equator. Draw the 0°, or prime meridian, through the circle printed on the map.

On your globe, with dividers and a ruler, measure the distance (in inches) between 15° of longitude on the line of the equator. ______________________ Do the same along the line of the 60° parallel of north [or south] latitude. ______________________

______________________ What is the ratio between these two distances? ______________________

______________________ On your map, as drawn, measure the distance between the equator and 15° north latitude. ______________________

Again, on your map, measure the distance between 52° 30′ north latitude and 67° 30′ north latitude (= 15°). ______________________ What is the ratio between these latter two distances?

______________________

From these observations complete the following sentence: On the Mercator projection map, the distortion in latitude distances is in the same ratio as the______________________

______________________ and directions are consequently represented as straight lines.

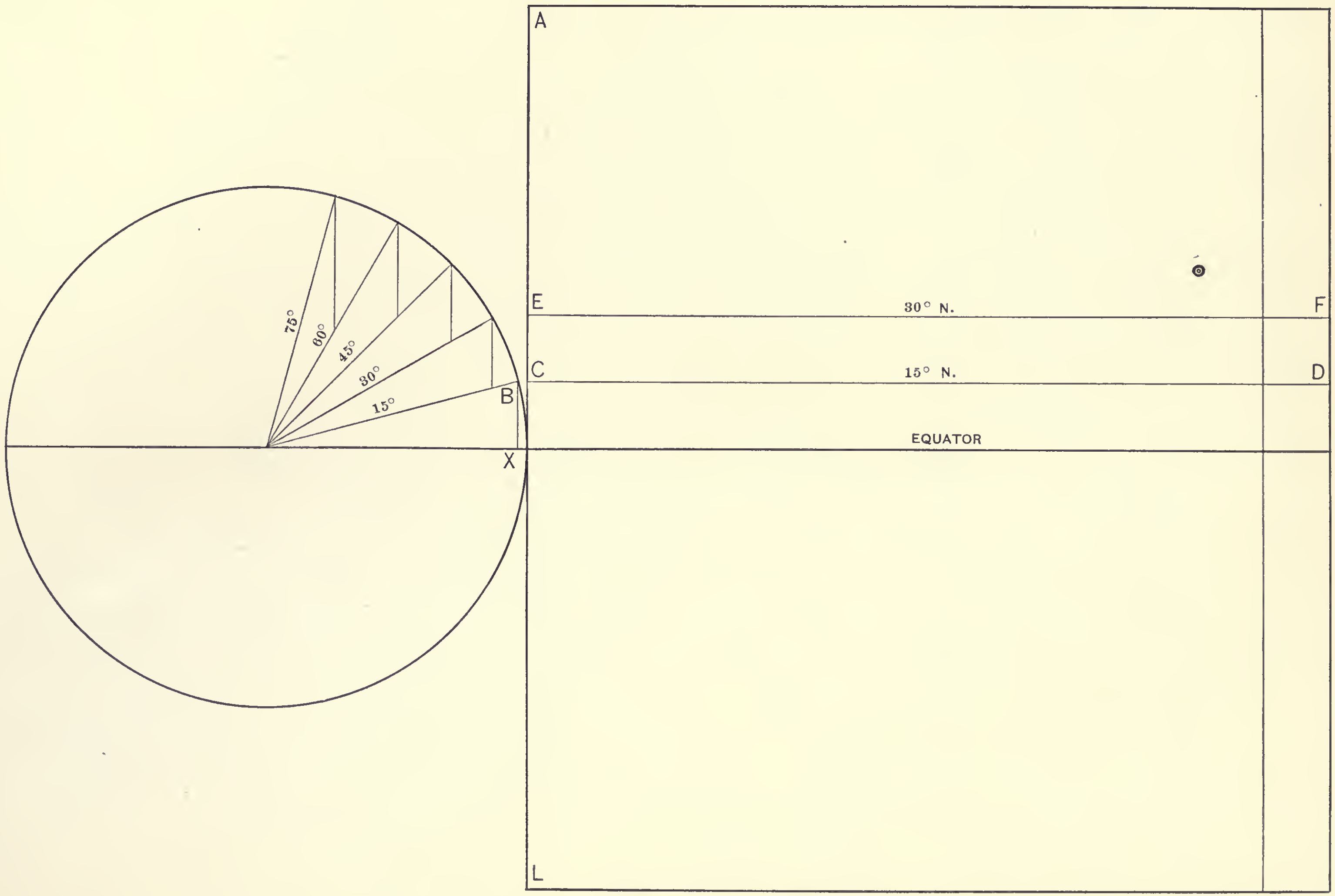



Fig. 3.—Construction of a Mercator Cylindrical Projection.

**Plotting in the outline of North America and South America.**

The little circle printed on the map represents the location of Washington, D.C., and is on the prime meridian as you have drawn your map. From your globe plot in the outlines of the continents of North and South America.

**Distortion of the Mercator Projection.**

Compare the outline of these continents on your globe and on the Mercator map you have constructed. Where and how does the Mercator projection distort areas? ________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Why, then, is no scale of miles given (except at times along the equator) on a Mercator map?

________________________________________________________________

________________________________________ Examine the maps in Figure 2 of this Manual and, by comparison with the globe, make observations as to their correctness in representing direction and distance. ________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

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________________________________________________________________

________________________________________________________________

**Curvature of earth on small areas.**

Calculate and draw a line showing the curvature of the earth's surface over a distance of 5 miles, mapped on a scale of 1 inch = 1 mile.

NOTE. — To find the amount of curvature of the earth's surface for any given distance, use the following rule: *Square the number of miles representing the distance. Two thirds of the resulting number represents in feet the departure from a straight line.*

*Calculation:* —

Draw line here.

How does this result apply to the amount of appreciable areal distortion shown in maps of small areas? ------------------------------------------------------------

------------------------------------------------------------

How does it compare to the amount of distortion on the world maps? ----------------------

------------------------------------------------------------

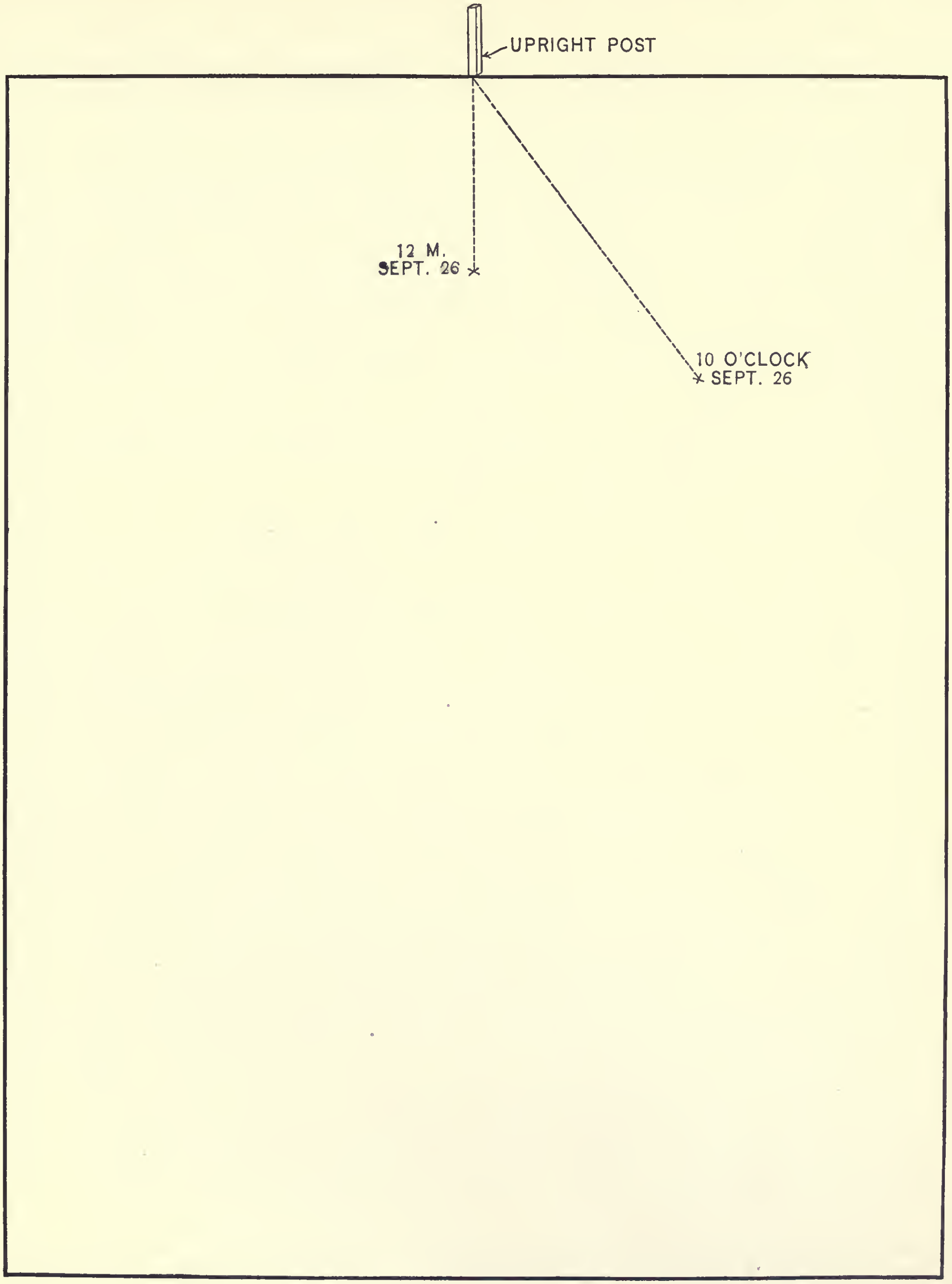


FIG. 4.—DIAGRAM OF APPARATUS FOR ESTABLISHING THE MERIDIAN BY THE SUN'S POSITION.

## VI. — DETERMINATION OF DIRECTION AND ESTABLISHMENT OF MERIDIAN

**Material.** **For Each Student. — Watch (when possible). Ruler. Pencil.**

**For General Class Use. — Rod. Cardboard.**

**Purpose.** *To study simple methods for determining the cardinal directions and for establishing a meridian by the sun's position.*

**Determination of direction by sun's position and use of watch.** Since the sun apparently revolves around the earth from east to west, it must at some time in its daily course be halfway between these two directions, and therefore where you live be due ____________________ (Add proper word.) At what time between sunrise and sunset would the sun be in this position? ____________________

With a watch in hand we can make use of the sun's position to determine approximately the cardinal directions, *i.e.* south, north, east, and west.

**Method.** Stand facing the sun; hold your watch so that the hour hand points directly to the sun; then a line from the center of the dial, and equally dividing the distance between the hour hand and the twelve o'clock figure, will point approximately south.

(To the Teacher. — Advise the students of the amount that standard time is slower or faster than sun time for your locality, and how to apply the correction.)

Try this experiment at different hours of the day. Do the results coincide? ____________________ When is there the greatest deviation? ____________________ Is there a deviation from day to day? ____________________

Facing south, what direction is at your back? ______________ To your right? ______________ To your left? ______________

**Establishing a meridian by sun's position.** Erect a thin rod of wood, or metal, six inches or more high, exactly perpendicular to the middle point of the long edge of a stiff piece of white cardboard. Put this cardboard on a smooth table top, carefully leveled, and place the table before a south-facing window with the edge of the cardboard which carries the rod toward the outside. Note the length and direction of the shadow which the rod casts on the cardboard by marking on the board, as accurately as possible, the length and direction *when the shadow is shortest.* Do this for several days. Set down the data on Figure 4. Get these data, if possible, on or near Sept. 23 or March 21.

What directions are determined by the line of the sun's shortest shadow? ____________________

**Suggested home work for students.** On a clear night locate the north star by means of the "Big Dipper," as shown in the diagram (Fig. 5). How well does your determination of north by the sun's position agree with the north as determined by the position of the north star? ____________________________________________

____________________________________________

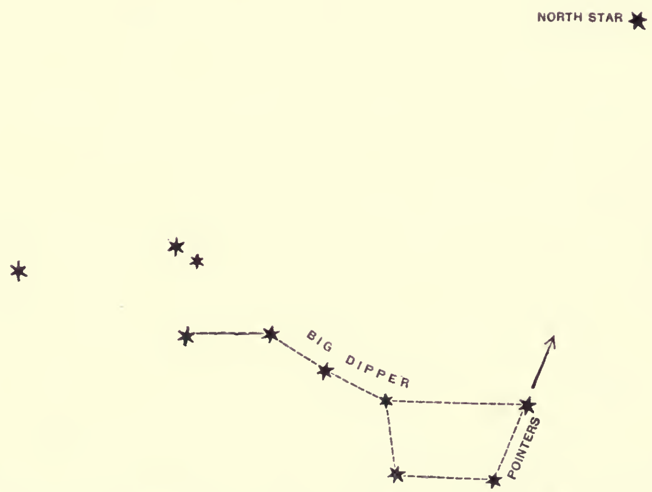


FIG. 5. — DIAGRAM TO ILLUSTRATE METHOD OF LOCATING NORTH STAR BY MEANS OF THE "BIG DIPPER."

Table to show the number of degrees to be added or subtracted on any given date in computing latitude by observation of the sun's position. + = add; — = subtract.

| Day of Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Degrees . . . . | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| September . . | + 8.3 | + 8.0 | + 7.6 | + 7.3 | + 7.0 | + 6.6 | + 6.3 | + 6.0 | + 5.3 | + 5.0 | + 4.6 | + 4.3 | + 4.0 | + 3.6 | + 3.3 | + 2.6 | + 2.3 | + 2.0 | + 1.6 | + 1.3 | + 1.0 | + 0.3 | + 0.0 | — 0.3 | — 0.6 | — 1.0 | — 1.3 | — 2.0 | — 2.3 | — 2.6 | |
| October . . . . | — 3.0 | — 3.3 | — 3.6 | — 4.3 | — 4.6 | — 5.0 | — 5.3 | — 5.6 | — 6.0 | — 6.3 | — 7.0 | — 7.3 | — 7.6 | — 8.0 | — 8.3 | — 8.6 | — 9.0 | — 9.3 | — 9.6 | — 10.3 | — 10.6 | — 11.0 | — 11.3 | — 11.6 | — 12.0 | — 12.3 | — 12.6 | — 13.0 | — 13.3 | — 13.6 | — 14.0 |
| November . . . | — 14.3 | — 14.6 | — 15.0 | — 15.3 | — 15.6 | — 16.0 | — 16.3 | — 16.3 | — 16.6 | — 17.0 | — 17.3 | — 17.6 | — 18.0 | — 18.0 | — 18.3 | — 18.6 | — 19.0 | — 19.0 | — 19.3 | — 19.6 | — 20.0 | — 20.0 | — 20.3 | — 20.3 | — 20.6 | — 21.0 | — 21.0 | — 21.3 | — 21.3 | — 21.6 | |
| December . . . | — 21.6 | — 22.0 | — 22.0 | — 22.3 | — 22.3 | — 22.3 | — 22.6 | — 22.6 | — 22.6 | — 23.0 | — 23.0 | — 23.0 | — 23.0 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.3 | — 23.0 |
| January . . . . | — 23.0 | — 23.0 | — 23.0 | — 22.6 | — 22.6 | — 22.6 | — 22.3 | — 22.3 | — 22.3 | — 22.0 | — 22.0 | — 21.6 | — 21.6 | — 21.3 | — 21.3 | — 21.0 | — 21.0 | — 20.6 | — 20.3 | — 20.3 | — 20.0 | — 19.6 | — 19.6 | — 19.3 | — 19.0 | — 19.0 | — 18.6 | — 18.3 | — 18.0 | — 17.6 | — 17.6 |
| February . . . | — 17.3 | — 17.0 | — 16.6 | — 16.3 | — 16.0 | — 15.6 | — 15.3 | — 15.3 | — 15.0 | — 14.6 | — 14.3 | — 14.0 | — 13.6 | — 13.3 | — 13.0 | — 12.6 | — 12.3 | — 12.0 | — 11.3 | — 11.0 | — 10.6 | — 10.3 | — 10.0 | — 9.6 | — 9.3 | — 9.0 | — 8.6 | — 8.3 | — 8.0 | | |
| March . . . . . | — 7.6 | — 7.3 | — 7.0 | — 6.6 | — 6.3 | — 6.0 | — 5.6 | — 5.0 | — 4.6 | — 4.3 | — 4.0 | — 3.6 | — 3.0 | — 2.6 | — 2.3 | — 2.0 | — 1.6 | — 1.3 | — 0.6 | — 0.3 | — 0.0 | + 0.3 | + 0.6 | + 1.3 | + 1.6 | + 2.0 | + 2.3 | + 2.6 | + 3.0 | + 3.6 | + 4.0 |
| April . . . . . | + 4.3 | + 4.6 | + 5.0 | + 5.3 | + 6.0 | + 6.3 | + 6.6 | + 7.0 | + 7.3 | + 7.6 | + 8.0 | + 8.3 | + 8.6 | + 9.3 | + 9.6 | + 10.0 | + 10.3 | + 10.6 | + 11.0 | + 11.3 | + 11.6 | + 12.0 | + 12.3 | + 12.6 | + 13.0 | + 13.3 | + 13.6 | + 14.0 | + 14.3 | + 14.6 | |
| May . . . . . . | + 15.0 | + 15.3 | + 15.3 | + 15.6 | + 16.0 | + 16.3 | + 16.6 | + 17.0 | + 17.3 | + 17.3 | + 17.6 | + 18.0 | + 18.3 | + 18.3 | + 18.6 | + 19.0 | + 19.3 | + 19.3 | + 19.6 | + 20.0 | + 20.0 | + 20.3 | + 20.3 | + 20.6 | + 21.0 | + 21.0 | + 21.3 | + 21.3 | + 21.6 | + 21.6 | + 21.6 |
| June . . . . . . | + 22.0 | + 22.0 | + 22.3 | + 22.3 | + 22.3 | + 22.6 | + 22.6 | + 22.6 | + 23.0 | + 23.0 | + 23.0 | + 23.0 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | + 23.3 | |

## VII. — DETERMINATION OF LATITUDE AND LONGITUDE

**Material.** **For Each Student. — Desk globe. Pencil. Ruler.**

**For General Class Use. — Rod and cardboard apparatus used in preceding exercise.**

**Purpose.** *A study of methods by which latitude and longitude may be determined for any given place.*

**Determination of latitude by the sun's noon altitude.**

On Sept. 23 and March 21 the sun is vertical at the equator. If you were at the equator, the sun would then be directly over your head at noon. Where would it appear if you were at either pole? ______________________________
What is the angular distance, in degrees, from a point in the sky directly overhead to a point on the horizon? ______________________ What is the angular difference, then, between the position of the sun on those two days to observers, one at the equator and the other at one of the poles? ______________________ How are the degrees of latitude numbered as one goes from the equator toward the pole? ______________
______________________________ How do the number of degrees of the sun's height above the horizon vary as one goes from the equator to the pole?

______________________________

Complete this sentence: The numbering of degrees of latitude grows ______________ as one goes from the equator toward the pole; and the altitude of the sun above the horizon grows ______________ as one goes from the equator toward the pole. Therefore, if one observes at any place the altitude of the sun in degrees, and subtracts that number from 90°, the result will be the number equal to the degree of ______________ of the place.

The sun's apparent course is north of the equator after March 21, *increasing* in altitude by a certain amount every day (see table on preceding page) up to June 21. To get the latitude on any day between these two dates one must add a correction (from the table) to the latitude as determined by the above method. Why do we add the correction? ______________

______________________________

______________________________

What correction must be applied between Sept. 23 and Dec. 21, when the sun is *decreasing* in altitude? ______________________________

Figure 6 is a diagram of the apparatus used in this exercise.

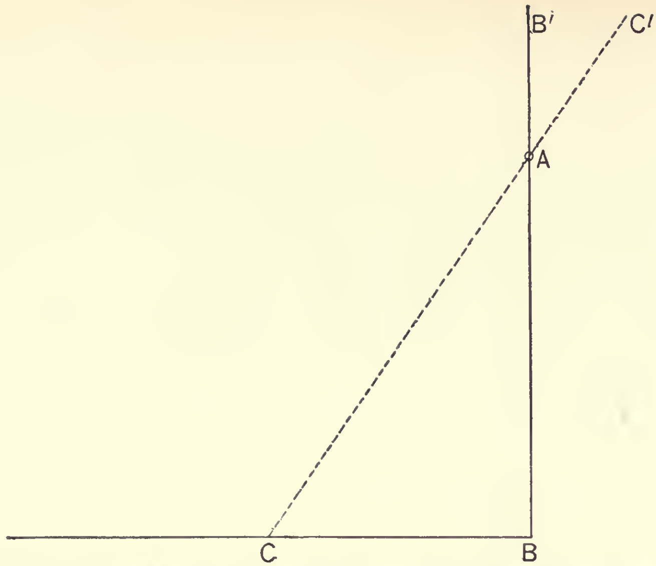


Fig. 6. — Diagram to illustrate a Method of finding Latitude.

*A–B*, the length of the rod; *C–B*, the length of the noon shadow; *BCA*, angle of the sun's altitude.

**Reading the angle of the sun's altitude.**

To read the angle of the sun's altitude, as observed, we need first to draw to scale our reading (as secured in the preceding exercise) of the length of the shadow and the length of the rod.

If you have studied geometry, prove that the angle $B'AC'$ is the angle of the latitude. To obtain the exact latitude, a correction must be applied to this angle, as you have learned above.

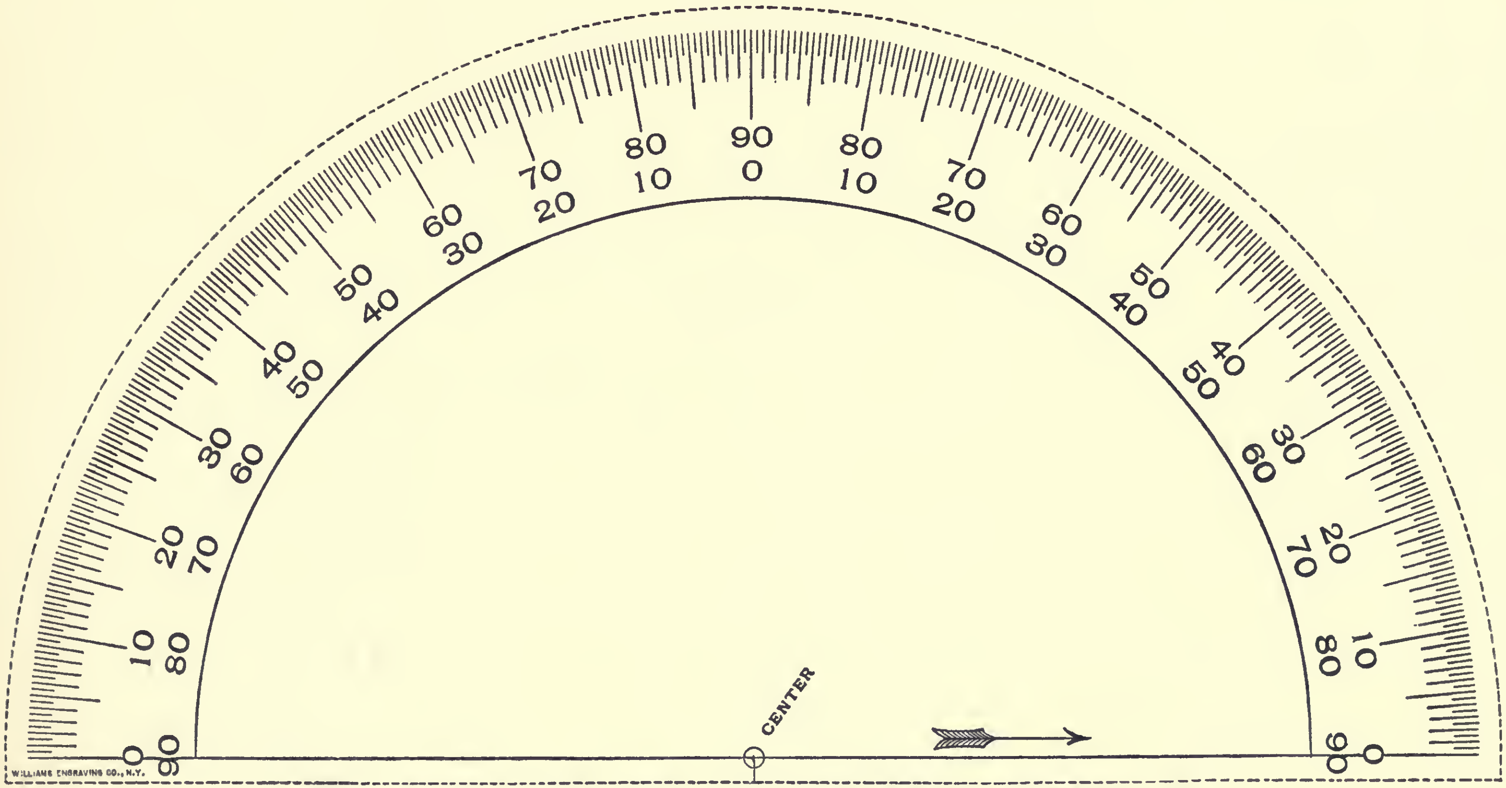


FIG. 7.—PROTRACTOR. (Note to Student.—Cut out this figure carefully along the dotted line.)

Next we need to use the *protractor* printed on the cardboard accompanying this exercise (Fig. 7). This is simply a half circle whose circumference is marked off in degrees and half degrees. Use the shears to cut it out carefully, as directed on the figure. Place the marked center of the protractor accurately on the extremity of the line of the shadow (by means of a pin stuck through the cardboard). Let the base line of the protractor coincide with the line representing the shadow. Then read off the angle made by a line from the center of the protractor to the top of the line representing the height of the rod; that is, the angle *BCA*.

The angle is ______________________ degrees.

The correction is ______________________ degrees.

The latitude as determined is ______________________ degrees north latitude.

How does this compare with the latitude as mapped on your globe, or any other map of your locality? ____________________________________________________________

**Suggested home work for students.**

The angle of the altitude of the north star is equal to the latitude of the place where the observation of the north star's position is made. The same reasoning that was applied to the position of the sun at the equator and the poles applies also to the north star, except that the positions are reversed; *i.e.* the north star is in the zenith (directly overhead) at the poles and on the horizon at the equator. Therefore the altitude of the north star gives the degree of latitude directly. Moreover, the north star does not change in position from day to day as does the sun; therefore, the observation can be made on any clear night and no corrections need be applied. (It is not deemed worth while to bring in here the variation between culmination points.)

Fasten the protractor, by tacks, to a smooth board, as illustrated in Figure 8. From the center point suspend a split shot by a thread for a plumb bob, as shown in Figure 8.

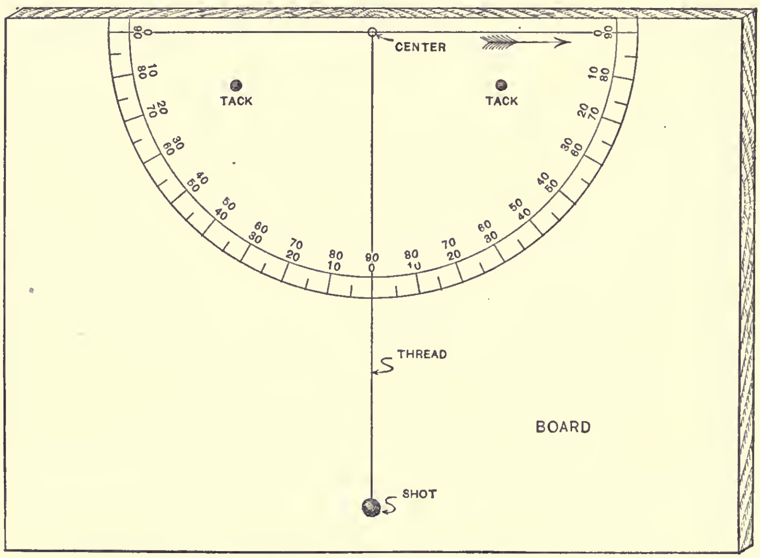


Fig. 8. — The Protractor used as a Quadrant Instrument.

**Determination of the latitude by observation of the north star.**

We are now ready to make the reading. Go to some point where the horizon line is uninterrupted. Point one end of the board (as indicated by the arrow) toward the north star, allowing the plumb bob to swing freely. When you have pointed the board accurately at the north star, hold the thread of the plumb bob firmly at the position to which it has swung. Now read the angle between the present position of the plumb bob and that which it had when the board was held horizontally. Make the observation a number of times and set down the result as indicated on page 53.

Reading No. 1. — Angle ________________________________________

Reading No. 2. — Angle ________________________________________

Reading No. 3. — Angle ________________________________________

Reading No. 4. — Angle ________________________________________

Average ________________________________________

How does this result compare in accuracy with that obtained by your sun observation? ____________

________________________________________________________________

________________________________________________________________

It is by application of these methods, with accurate instruments and refined corrections, that sailors and explorers determine their latitude. Find out what a *sextant* is.

**Determination of longitude.**

(Use your desk globe in finding answers to these questions.) How many degrees are there in the circumference of a circle? ________________________ How many hours does it take the sun to seemingly go around the earth? ________________________

Therefore, over how many degrees of longitude does it pass in one hour? ________________

________________________ Is there any difference in the number of degrees of longitude the sun passes over at the equator and at other latitudes, such, for example, as 45° N. latitude?

______________ When it is noon at Washington on a certain day, what time is it on the same meridian to the north and south of Washington? ________________________

Where does the sun rise? ____________________ Where does it set? ________________

Which places have noon first on a certain day, those to the east or to the west? __________

______________________________________ If at the same actual time it is noon at Greenwich, England (consult your globe), and seven o'clock in the morning at Philadelphia, U.S., what is the longitude of Philadelphia as compared to that of Greenwich? ______________________________

________________________ If now you set a very accurate watch (chronometer) exactly at noon for Greenwich, or any meridian, and then start from there on an exploring expedition to South America, how, by consulting this chronometer, can you tell the longitude of different points in South America? ________________________________________

________________________________________________________________

What advantage would there be in carrying several chronometers, all accurately set for Washington time, or that of some other meridian? ________________________________________

________________________________________________________________

---------------------------------------- If there is a telegraph line extending from a place, of which you know the position, to one whose longitude you wish to determine, how could the telegraph be utilized to great advantage in the determination? ------------------------------

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## VIII. — ROTATION AND ITS EFFECTS

**Materials.** **For Each Student. — Desk Globe. Dividers.**

**For General Class Use. — Cardboard and Rod Apparatus.**

**Purpose.** *To understand how rotation governs daily change in time; the significance of standard time; and of date line.*

**Day and night.** Place your globe in a strong light. How much of it is illuminated? ________________

How much of it is in the shadow? ____________________ What do these areas determine on the earth, when illuminated by the sun? ________________________________________

____________________________________________ Between the lighted and unlighted parts is a belt all around the globe which is partly lighted and partly in shadow. To what times in the day would this belt correspond? ____________________________________________

____________________________________

**Sunrise and sunset.** Which way does the sun seem to move? ____________________________________

____________________________________________ If the sun is standing still and the earth is rotating, in which direction must it turn? ____________________________________________

____________________________________________ Slowly rotate the globe in the same direction. Is it moving clockwise or counter-clockwise? ____________________________________

Stop the rotation when the conditions are such that the sun is just rising over your home. Where is it then setting? ____________________________________________________

_________________________ Where is the twilight zone? ________________________________

_____________________________________________________

**Difference in time.** How long does it take the earth to make one complete rotation? ____________________

_____________________ Look on the globe to see how many degrees of longitude, east and west, are marked on the equator. What is the sum of these? ________________________________

____________ How many degrees, then, must the sunrise pass over in one hour? ________

__________ In two hours? _________________ In six hours? _________________ Rotate the globe to see that the sunrise extends farther and farther westward on the equator as the globe rotates. Is the same thing true at latitude 45°? _______________ At latitude 60°? _______________ Does an object move faster or slower at the equator than at latitude 45°? _______________________ Why does the sunrise pass over the same number of degrees of longitude in an hour in the two places? ________________________________________________

________________________________________________________________________________

_________________________________ Now, state why there is an hour's difference in sunrise at every fifteenth degree. ________________________________________________________

________________________________________________________________________________

__________________________ Is there the same difference in noon? ______________ In sunset? _______________ To the north of the equator? _______________ To the south of the equator? _______________ How much difference in time is there in one degree? ______________________ _______________________ Is the time of day earlier or later to the east? ____________________ To the west? ____________________ What about the time north and south along a given meridian? ________________________________________________________________________

**Problems.** When it is sunrise at 70° west longitude, is it before or after sunrise at 100° west longitude? ______________________________________________________ How much is the difference? ____________________________________________________ What is the difference in time of sunrise between 70° west longitude and 10° west longitude? ____________________________________________ Between 70° west longitude and 10° east longitude? ____________________________________________

When it is midday at your home, where is it midnight? ______________________________ ___________________ When the people in London (at 0° Long.) are rising, say at 7 o'clock, what is the time at your home? ________________________________________ By study of your globe find the difference in time between (*a*) Chicago and San Francisco; __________________ (*b*) New York and Peking; _______________ (*c*) New York and Chicago; __________________ (*d*) New York and Rome. ______________ In each case state which city has the earlier time.

________________________________________________________________________________

________________________________________________________________________________

**Local time.** (NOTE. — Use the cardboard and rod apparatus, see Exercise VI.)

On a board placed in the sunlight set up a rod about six inches high. At half-past eleven mark with a pencil where the end of the shadow of the rod falls on the board; also marking the time on the board. Be sure that your watch is exactly right. Every five minutes after that, mark the position (and time) of the end of the shadow until half-past twelve. Then connect the points. Carefully measure (with dividers) the distance between the points marked and the base of the rod. Which point is the shortest distance from the rod? That point marks the time of local noon. Why is that so? ____________________

________________________________________

________________________________________

____________________ Was it also noon by your watch?

__________ If not, how much difference was there? __________

**Standard time.**

What objection is there to the use of local time? ____________________

________________________________________

________________________________________

____________________ How have the difficulties been met?

________________________________________

Why should Greenwich be chosen as the place to start in reckoning standard time?

________________________________________

________________________________________

On what meridian is the standard time one hour later than at Greenwich? __________

__________ Two hours? __________

Five hours? __________ On the outline map of the United States (Fig. 9) locate the meridians 75°, 90°, 105°, and 120° West Longitude. Why should these meridians be chosen as the central meridians for our time belts? __________

________________________________________

________________________________________

________________________________________

________________________________________

________________________________________


FIG. 9. — OUTLINE MAP OF THE UNITED STATES.

On the map (Fig. 9) sketch in the four standard time belts of the United States. (See Fig. 556, p. 404 of Text-book.) Why are the actual boundaries irregular and not on the meridians?

In which of the standard time belts do you live?

Where and how much would you change your watch in going from New York to San Francisco?

From Chicago to Boston?

**The date line.**

If a person should travel completely around the earth, going from east to west, how many times (and in which direction) would he have to change his watch if he made the change every fifteen degrees?

On his return how would his time agree with that of his starting place?

Would he have gained or lost a day?

What would be the case in traveling around the earth in an easterly direction?

If it is sunrise Monday where you live, would it also be Monday when the sun next rises at the Hawaiian Islands? ________ In China? ________ In London? ________ In New York? ________ What difficulty does this bring out? ____________________

____________________________________________

____________________ Where does Tuesday begin? ________

____________________________________________

Where would *you* begin it? ____________________

____________________________________________

____________ What objections would there be to choosing a meridian running through a country such as England, or Germany, or the United States? ____________________

____________________________________________

____________________________________________

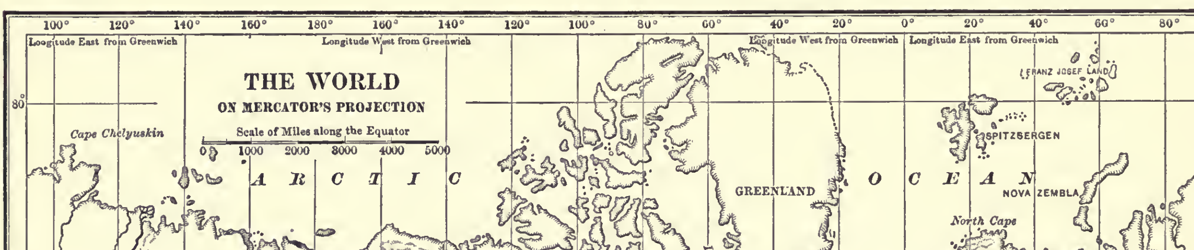


FIG. 10. — MAP OF WORLD FOR PLOTTING THE INTERNATIONAL DATE LINE.

---------------------------------------------------- Such a line would be called a *date line*. Find the date line on your globe. What reason can you suggest for locating the date line where it is?

---------------------------------------------------------------------------------------------------

Does the date line follow a meridian exactly? ------------------ Draw in the date line on the map of the world (Fig. 10). If you crossed that line Monday, June 20, coming from the east, what would be the

day of the week and month on the other side of the line? --------------------------------------------

---------------------------------------------------- What if you were coming from the west?

---------------------------------------------------------------------------------------------------

Indicate this on the map, showing both routes by arrows, and on each side of the date line writing the days and dates going each way.

## IX. — THE SEASONS

Materials. **For Each Student. — Desk globe. Cotton string. Colored pencils.** (Method of using string: Tie tightly around globe at equator, then slip over globe in the positions indicated below.)

Purpose. *To understand how the earth's revolution around the sun, together with the inclination of the earth's axis, determines seasons, zones, and length of day and night.*

Local observations. At what season is the sun highest in the heavens at noon where you live? ____________

____________________________ At what season lowest? ____________________________

At what two opposite seasons is the sun halfway between the highest and lowest? ________

____________________________________________________________

At what seasons does the sun rise exactly in the east and set in the west? ______________

____________________________________________ At what season does

it rise and set farthest south of true east and west? ____________________________

Farthest north of true east and west? ____________________________

In a few sentences write a description of the changes in the sun's position for a year.

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

What is the cause of these changes? ____________________________

____________________________________________________________

____________________________________________________________

____________________________________________ What is revolution?

____________________________________________________________

____________________________________________________________

How much is the earth's axis inclined? ____________________________

Winter season. Set your globe on the desk in front of you with its axis inclined $23\frac{1}{2}°$, and with the north-pole end pointed away from you. (Your desk globe is probably set at this inclination.) Look at the globe with your eyes on the level of the Tropic of Capricorn. Can you see the south pole?

--------------- The north pole? --------------- If you held a lighted candle where your eyes were, how much of the south polar region would be lighted? -------------------------- -------------------- Of the north polar region? ------------------------------------------

Where, on the surface of the globe, would the light fall most directly? ------------------ ------------------------- Place the string around the globe to show the limits of the lighted part in this position. To what latitude does it extend in the north? ---------------------- ----------------------- How far does it go beyond the south pole? ----------------------- -------------------- Now rotate the globe. Under these conditions is there any night in the Antarctic region? --------------- Is there any day in the Arctic region? --------------- Is there day and night in the equatorial region? --------------- In which hemisphere is the period of daylight longest as the globe rotates? ------------------------------------------ Letting the globe represent the earth, and the light the sun, in which hemisphere is the sun most nearly vertical? --------------------------------------------- Is this period summer or winter at your home? ------------------- What season is it in the southern hemisphere? ---------------------------- Why is it warmer at the equator than in the Antarctic region?

------------------------------------------------------------------------------------------

Why warmer in the Antarctic than in the Arctic? ------------------------------------------

------------------------------------------------------------------------------------------

--------------------------------------------- Briefly describe the changes in the sun's position, and length of day, that one would observe in passing from the south to the north pole at this season. ------------------------------------------------------------------------------

------------------------------------------------------------------------------------------

------------------------------------------------------------------------------------------

------------------------------------------------------------------------------------------

------------------------------------------------------------------------------------------

------------------------------------------------------------------------------------------

**Summer season.** Swing the globe around to the desk behind you, as if your body were the sun, keeping the axis always inclined *in the same direction.* Now the north pole points toward you. With your eyes at the same level as when you looked at the globe in the winter position, what part of the globe is directly in front of them? ______________________________

Again, imagine a lighted candle placed where your eyes are; the light would fall most directly on the Tropic of Cancer. Place the string around the globe to show the limits of the part that would be illuminated if a strong light fell upon the globe when in this position. How much of the north polar region would be lighted? ______________________________

Of the south polar region? ______________________________ Rotate the globe.

Is there any night in the Arctic region? ______________ Is there any day in the Antarctic? ______________ What parts of the earth have day and night? ______________________________ ______________________________ In which hemisphere is the period of daylight longest as the globe rotates? ______________________________

Letting the globe represent the earth, and the light the sun, in which hemisphere is the sun most nearly vertical at this season? ______________________________ What season does this represent in the northern hemisphere? ______________________________ In the southern? ______________________ Why is it warm at the equator? ______________________ ______________________________ Why is there no winter there? ______________________________

In which direction will a shadow fall at the equator at noon? ______________________________ ______________ At the Tropic of Cancer? ______________________________

At the Arctic circle? ______________________________ At the Tropic of Capricorn? ______________________________ Where will the shadow be longest? ______________________________

Explain why the sun rises and sets farther north at this season than in the winter.

______________________________

______________________________

Briefly describe the changes in the sun's position and the length of day that one would observe in passing from the north to the south pole at this season. ______________________________

______________________________

______________________________

**Spring and autumn.** Swing the globe around to the desk on your left, with the axis still pointing as before. This will represent March 21. With your eye at the same level as before, you now look directly at the equator. Place the string on the globe to show the area lighted in this position. What part of the surface must then receive vertical sun's rays? ________________ Does the north pole receive sunlight in this position? ________ The south pole? ________ In what proportions does the string divide the equator? ________________

Rotate the globe. How many hours of sunlight would a place on the equator have? ________________ Therefore, how many hours of night? ________________ Does the string divide other parallels equally? ________ At this period, how long is the day and night in all parts of the earth? ________________ Why is this called the spring *equinox?* ________________ Does the sun also rise and set in the Arctic and Antarctic regions at this season? ________ How does the sun appear at the poles themselves? ________________

Swing the globe around to the desk on your right, with the axis still pointing as before. Answer the same questions as for the last position. ________________ Why should this period (Sept. 23) be called the autumnal equinox? ..................................................

.................................... By placing the globe in other positions, show that there is no other season besides autumn and spring when the days and nights are equal all over the earth. Where would they be equal on Dec. 21? ..................................................

.................................................. On June 21? ..................................................

..................................................

Make a drawing (see Fig. 553, p. 401, in Text-book) to show the revolution of the earth about the sun, fixing the position for June 21, Sept. 23, Dec. 21, and March 21, and shade the half of the globe to represent night at each of these dates.

**The zones.** What reason can you give for placing the Tropic of Cancer, Tropic of Capricorn, Arctic Circle, and Antarctic Circle where they are? ..................................................

..................................................

.................................................. What is the latitude of each?

..................................................

..................................................

..................................................

What reasons can you give for the fact that the torrid zone is warm at all seasons?

For the fact that the temperate zones have warm summers and cold winters?

For the fact that the frigid zones are cold even in summer?

On the outline map (Fig. 11) sketch in the five zones with different colored pencils, and write in their names. Why would you not expect to find an abrupt change in going from one zone to the next?

**To find the length of day and night.**

Place the string on the globe in the position of the equinox. What is the number of degrees of longitude on the lighted side at the equator? At 45°? At 60°? Remembering that 15° of longitude represents one hour of time, how many hours long is the day at the equinox? The night? Shift the string to the position of midwinter (Dec. 21). How many degrees are lighted at the equator? At the Tropic of Capricorn? At 45° N. latitude? At 45° S. latitude? At your own home?

What is the length of daylight at each of these parts of the earth on Dec. 21?

With the string in the midsummer position (June 21) make the same observations for that date.

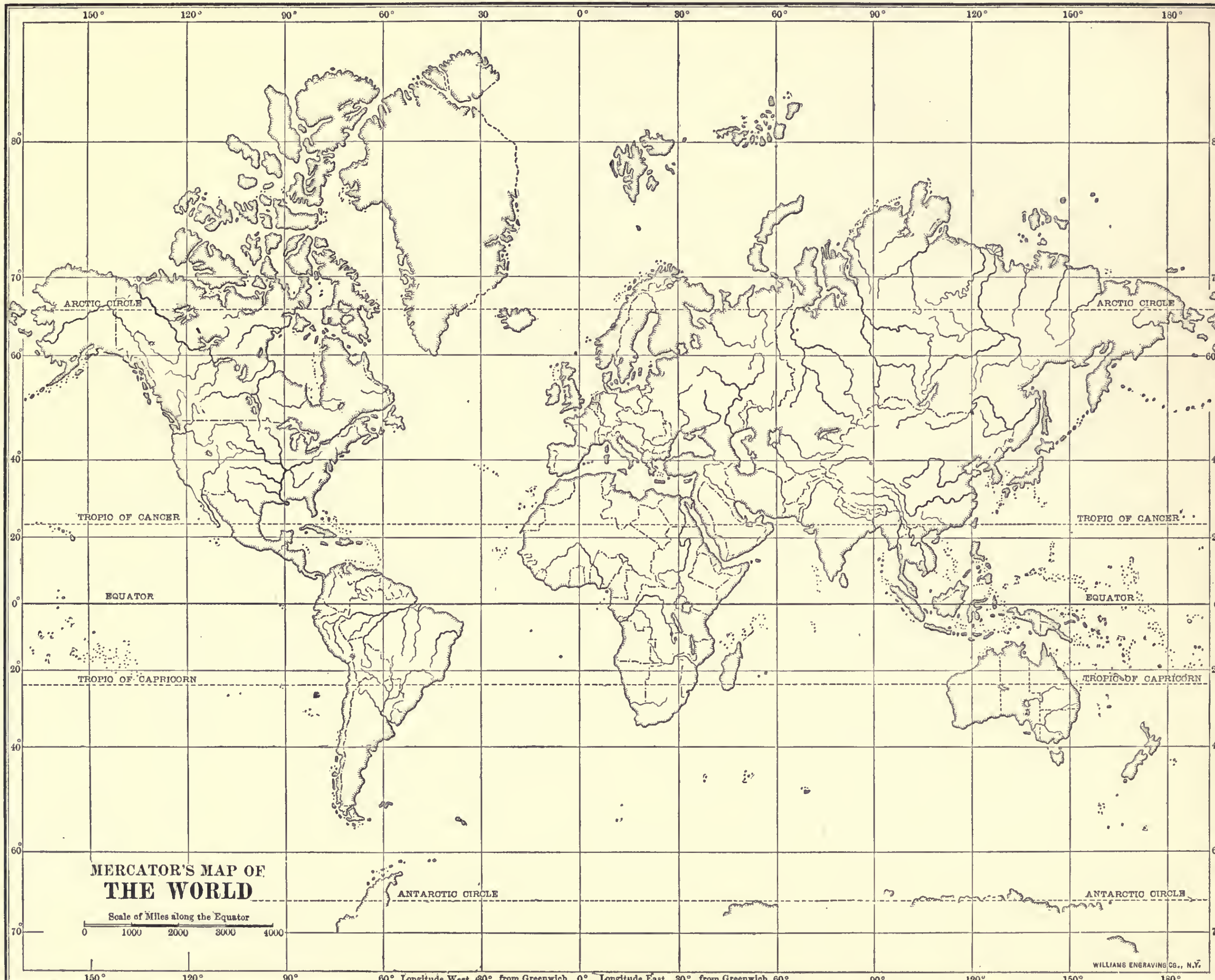


FIG. 11. — OUTLINE MAP OF WORLD FOR COLORING IN ZONES.

## X. — FIELD EXCURSION FOR COLLECTION OF SPECIMENS

**Materials.** **For Each Student. — A bag, or small basket, for carrying specimens.**

**For General Class Use. — One or more hammers.**

**Purpose.** *To collect specimens (such as minerals, rocks, and fossils), for later study in the laboratory; to gain a knowledge of the nature and characteristics of the bed rock; and to study the soil.*

**Introductory.** For this excursion select the nearest rock outcrop within easy reach; and, if possible, on the way to it examine one or more bowlders. If different rock outcrops are accessible on this excursion, examine several.

**The rock outcrop.** Describe the appearance of the outcrop ______________________

______________________________________________

______________________________________________

______________________ Was it revealed by the work of man, or of water, or is it a hillside ledge with no soil on it? ______________________

______________________ What is the color of the rock? ______

______________________ Is it hard or soft? (Try the effect of a hammer or knife on it.) ______________________ Is its texture coarse or fine-grained? ______________________ Can you see individual minerals in it?

______________ If so, describe their appearance. ______________

______________________________________________

______________________________________________

______________________________________________

Is the rock in layers or not? ______________ If in layers, what differences are there between them? ______________________

______________________________________________

______________________________________________

Are the layers horizontal or inclined? ______________________

Are there any fossils? ________ If so, collect specimens. After the teacher has told you what a sedimentary rock is, tell whether this is a sedimentary or a crystalline rock. ________ How is a sedimentary rock distinguished from a crystalline rock? ________

________ There are many kinds of sedimentary and crystalline rocks. The teacher will tell you the name of this one. Write a brief description of it.

Collect a specimen for study in the laboratory when you are studying minerals and rocks.

When a rock is subjected to strain, as is often the case in the earth's crust, it breaks, forming a parting called a joint plane. Are there joint planes in the outcrop? ________ Write down any other observations you make, or any facts that the teacher tells you about this outcrop. ________

**Soils.** Is there soil resting on the rock outcrop? ________ Examine and describe it, stating whether it is coarse or fine ________; whether it is different at the top and bottom ________

________________; whether it has pebbles in it or not ____________________________________;

whether it grades down into the rock or is separated sharply from it ______________________

________________________________________________________________; and any other observations

you may make. ________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

**Other minerals and rocks.** On your way from the outcrop watch carefully for bowlders and pebbles. Do you find any? ______________ Are they like the rock in the outcrop? ______________ If not, collect specimens for study in the laboratory.

## XI. — EXCURSION FOR THE STUDY OF WEATHERING

**Materials.** **For Each Student. — A small bag or basket for the collection of specimens.**

**For General Class Use. — One or more hammers.**

**Purpose.** *To study in the field some of the processes by which rocks are disintegrated or broken down on exposure to air.*

**Introductory.** The class should be taken to some rock outcrop, or failing that, to a bowlder. If several outcrops are available, select the one at which it is possible to answer the largest number of the following questions. Almost any outcrop will furnish opportunity to make some observations on weathering.

**Effect of expansion and contraction.** Is the rock of this outcrop composed of one or of several kinds of minerals?

............................................. Heat causes minerals to expand, and they contract when cooled. Different minerals expand and contract at different rates. As this outcrop is warmed in the day and cooled at night, what must be the changes in the rock as a whole? ....................................................................................

What must happen as a result of the strains at the junction of minerals of different kinds?

....................................................................................

....................................................................................

State briefly how changes in temperature aid in the disruption of rocks where they outcrop.

....................................................................................

....................................................................................

....................................................................................

....................................................................................

....................................................................................

**Effect of frost.** Are there any visible cracks in the rocks? ............... When might water enter the rocks? ....................................................................................

Does water expand or contract on freezing? ..............................................

When the cracks are filled with water and the temperature falls below freezing point, what is the effect of the freezing of the water in the cracks? ..............................................

.................................................. Are there other smaller cracks in the rock, — for instance, between the mineral grains? What influence do these have in aiding in the breaking up of the rock?

Write a brief paragraph stating the effect of frost in rock disintegration.

**Effect of plants.**

Are there any lichens on the outcrop? How do they cling to the rock?

As the lichens grow, how do they aid in rock disintegration?

Are there any bushes or trees sending their roots down into the rock? What effect will the growth of these roots have on the rock?

**Solution.**

As the rain water passes through the soil it takes with it certain substances (like carbon dioxide and humic acids) supplied by plant decay. The water then has power to dissolve some minerals. Where, in this rock outcrop, will water percolate most freely?

If it flows along a joint plane, what effect will it have on the rock on either side?

If it slowly percolates between the mineral grains, what effect will it have on them?

State how the work of solution aids rocks in crumbling.

Have you ever seen an iron spring, or a sulphur spring, or other kind of mineral spring?

Why are such springs called mineral springs?

How did the water obtain its load of dissolved mineral?

"Hard water" is water with mineral matter in solution. How did this get in solution?

**Decay of rocks.**

Percolating water not only dissolves some minerals, but it causes some to change greatly, as iron is caused to change to rust. Break off a piece of the rock to see whether any of the minerals show such a change. Describe the difference between the outer and inner parts of the piece of rock.

Are any of the minerals rusted red or yellow on the outside? Are any of them changed to dull whitish color? If one kind of a mineral in a rock decays, and the other does not, how does that weaken the rock as a whole?

State briefly how decay results in rock disintegration.

Make a list of the agencies of weathering that you have observed at this outcrop.

Add to the list any other agencies of weathering that you know about, but have not observed.

**What becomes of the disintegrated rock.**

As the rock of this outcrop disintegrates, what becomes of the fragments?

Do any fall to the base of the cliff, forming a talus? Describe the talus and explain its formation.

Are any of the fragments carried off by streams?

Are any taken away by plants? How?

What becomes of the dissolved mineral?

Make a brief statement to show what becomes of the products of rock weathering.

**The formation of soil.** If the slope of the bedrock is so gentle that the products of weathering are not all removed, a mantle of soil is formed, called a *residual soil.* How would such a soil differ in character from the surface to the bedrock? ______________________________________________

______________________________ How would the roots of plants aid in making the soil finer?

What effect would earthworms have on the texture of the soil? ____________________________

______________________________ Why would a residual soil be different on different kinds of rocks, such as limestone, slate, and granite? ______________

______________________________ Would a residual soil grade into the bedrock, or would there be a sharp line separating them? __________

______________________________ What is the nature of the soil on this outcrop? ______________________________ Describe it.

Is it a residual soil? ______________

**Other observations.** Write down any other observations you have made on this excursion, or any other facts you have learned. If you have ever noted the effect of weathering elsewhere, as on bowlders, or on stone buildings, or on the headstones in cemeteries, state what you have observed.

## XII.—EXCURSION TO STUDY STREAM WORK

**Purpose.** *To study the work of streams in eroding their valleys and forming deposits.*

**Introductory.** The banks of a comparatively small stream whose current is alternately swift and sluggish will best serve the purpose of this excursion. Any water course will, however, give an opportunity for profitable work, even though some of the observations outlined cannot be made. Failing a perennial stream, the course of a wet-weather stream along a roadside or elsewhere will afford many illustrations of stream processes.

**Transportation of sediment.** Is the water clear or cloudy? ______________ If it is not clear, what causes the cloudiness? ______________

______________

______________

______________ How are clay and other fine earthy particles carried along by the current? ______________

______________

______________ What is the nature of the bottom of the channel at this point?

______________

______________

Was the material of which it is composed brought by the current? ______________ If so, was the current faster or slower at the time when the material was deposited? ______________

______________ How do you know this? ______________

______________

______________

______________

If the stream is flowing over bedrock, what does this fact indicate as to the transporting power of the stream at this point? ______________

______________

______________

Examine, if possible, a place in the stream course where the water is shallow and flowing rapidly. What kind (as to size and nature) of particles are being rolled along on the bottom?

------------------------------------------------------------

------------------------------------------------------------

Throw pebbles, sand, and clay into the current to see how coarse material can be transported.

------------------------------------------------------------

Would larger or smaller particles be moved at flood times? ------------------------------

Why? ------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

What evidence of this is afforded by the bowlders and pebbles in the bed of the stream at different points in its course? ------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

When may they be moved again? ------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

**Erosional work of streams.**

Have the bowlders and pebbles in the stream bed rounded or sharp corners? ------------------------------ Why? ------------------------------

------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

What does this indicate as to the way in which the material of a bowlder or pebble will eventually reach the sea? ------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

------------------------------------------------------------

What will be the effect on the bedrock as the pebbles and bowlders are rolled over it?

What effect will the transportation of sand particles have?

What will be the effect, in both cases, on the depth of the stream channel?

What is the source of the material which the stream carries?

How does weathering assist the stream in securing this material?

How are stream valleys deepened?

Is the course of the stream a straight line?

What is meant by a meandering course?

What work is the current doing where it swings toward the bank in a meander curve?

What effect will this have on the width of its channel?

How does weathering aid in the widening of stream channels?

What illustrations of this do you find here?

Why have ripraps and embankments been built by man along many streams?

**Deposition of sediment.**

Where are bars formed in the stream's course?

Of what materials are they composed?

How do you account for their presence and composition in each case noted? ____________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

When will this material be moved again? ______________________________________

______________________________________________________________________

__________________________________________ Where will it ultimately be deposited?

______________________________________________________________________

Is sediment carried in one continuous journey from its starting place to the sea? __________

Describe the process. ______________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

What forms may the material take when deposited in the sea or a lake? ________________

______________________________________________________________________

____________________________________________________________ What illustrations of

this do you find in the small pools or ponds in the stream course? ______________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Write a short paragraph summarizing the work of streams in deepening and widening their valleys and in forming sedimentary deposits.

## XIII.—EXCURSION TO LAKE OR SEA COAST

**Purpose.** *To study the waves and currents on a coast line; to note their importance in erosion, transportation, and deposition; and to study some of the land forms resulting from their action.*

**Introductory.** Even the shore of a very small pond will often illustrate the main phenomena which it is the purpose of this excursion to study; therefore, if a large lake or a sea coast are not accessible, this excursion may nevertheless be undertaken with profit.

**The wave.** Are there any waves on the water surface? ______________ About how high are they? ______________________________ What is the cause of the waves? ______________________________

______________________________________________________________________

At what time are the waves higher than now? ______________________________________________

______________________________________________________________________

As the waves approach the coast, how do they change in form? ______________________________

______________________________________________________________________

______________________________________________________________________

Are there points where the waves reach the coast with greater vigor than others? ______________

What reason can you give for their greater vigor in such places? __________________________

______________________________________________________________________

______________________________________________________________________

**Currents.** Is there a tide on this coast? ________________ If so, describe it. ____________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Does the tide cause currents in any place? ________________ When the wind blows steadily over a body of water, what other movement of the water is there besides that of the waves?

______________________________________________________________________

Is a wind-formed current a rapid or a slow movement? ____________________

How does such a current compare in power with the waves? ____________________

____________________

Can it transport coarse sediment? ____________________ Clay? ____________________

**Wave work on headlands.** Do the waves beat against a headland at any point on this coast? ____________________

Is the headland hard rock or unconsolidated material? ____________________

Is it steep or gently sloping? ____________________ What evidence is there that the waves are working to erode the headland? ____________________

____________________

____________________

____________________

How does weathering assist in the work? ____________________

____________________

____________________

If this work of erosion continues, what change will take place in the form and position of the headland? ____________________

____________________

____________________

Is such work most rapid in consolidated or in unconsolidated material? ____________________

____________________ As weathering and wave erosion remove material, what becomes of the fragments? ____________________

____________________

____________________

**Wave work on beaches.** Of what is the beach made? ____________________

____________________ As the waves wash up on the beach, what size material—clay, sand, or pebbles—do they move? ____________________

What size material can the waves move in times of storm? ____________________

____________________

What relation, if any, is there between the beach material and the headlands? ____________

________________________________________________________________

________________________________________________________________

How was the beach material brought to its present position? ____________________________

________________________________________________________________

________________________________________________________________

As the waves move the beach material about, what change in size of particles results?

________________________________________________________________

Where are the finer particles, such as clay, carried? ______________________________________

______________________________________ How do the wind-formed currents aid in this transportation? ______________________________________________________

The undertow? ______________________________________________________________

How does such transportation aid in explaining the absence of clay beaches? ____________

________________________________________________________________

________________________________________________________________

In explaining the frequency of clay deposits in protected bays where currents enter?

________________________________________________________________

________________________________________________________________

In explaining the fact that clay often covers the bottom at a short distance from the beach?

________________________________________________________________

________________________________________________________________

**Animal and plant life.** Are there any animals or plants living in the zone reached by the waves? ______________ What kinds? ______________________________________________________

________________________________________________________________

Do they aid or retard the work of the waves or currents in any way? ____________________

________________________________________________________________

________________________________________________________________

**Other observations.** What other phenomena are illustrated on this coast? ______________________________

________________________________________________________________

Does ice, for instance, ever form here; and what effect does it have?

Is the coast line a place of rapid or slow change?

Are there ripple marks? Study their formation and explain them.

State any observations you may make on the work of the wind in drifting sand about.

What observations have you ever made on other coasts than this one?

**Form of the coastline.**

Is the coastline straight or irregular? ______________ Is it a raised or a lowered coast? ________________________________________ Have the waves and currents produced much or little change on this coast? ____________________________________________

Are they now causing much or little change? ________________________________________

Briefly describe the coast as you have observed it; state how the agencies of denudation are modifying it, and explain its present form so far as the facts you have seen enable you to do so. ________________________________________

## XIV. — PROPERTIES OF MINERALS

**Materials.** **For Each Student. — Fragments of quartz crystal, feldspar, hornblende, halite (salt), biotite mica, calcite, gypsum. Steel knife or scratch point. Window glass (fragment).**

**For General Class Use. — Dilute hydrochloric acid, and several glass stirring rods; or acid-dropping bottles.**

**Purpose.** *To learn the properties by means of which the more common minerals may be identified and distinguished.*

**Introductory.** A mineral may be defined (in general terms) as any inorganic solid, formed in nature, which is composed of certain elements in definite combinations. The nature of the elements, the amounts of each present, and the way they are combined give each mineral its own peculiar characteristics. Thus a mineral is a naturally formed solid which has the same composition and structure throughout its mass.

**Method of study.** Number your specimens from 1 to 7. Then make the observations as directed below and record the results. Refer to each specimen by the number you have given it.

**Color.** Which specimens are light colored? ______________________________

Which are dark? ______________________________ What is the color of No. 1?

______________ Of No. 2? ______________ No. 3? ______________

No. 4? ______________ No. 5? ______________ No. 6? ______________

No. 7? ______________

**Hardness.** If one mineral scratches another, which is the harder, the one scratched or the one used to scratch with? ______________________________

| Number of Specimen | Numbers of Specimens which it scratches | Numbers of Specimens which scratch it |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

By using a sharp point or corner of each specimen to scratch with, and selecting a flat place to scratch on, try to scratch each mineral with every other one and set down your observations in the table opposite. Be careful not to press so hard as to break off the points by mere weight.

Which of the seven is the hardest specimen? ______________ Which is the softest? ______________ Arrange the specimens in the order of their hardness, putting the hardest first.

| Hardest | Next Hardest | Third Hardest | Fourth Hardest | Fifth Hardest | Sixth Hardest | Softest |
|---|---|---|---|---|---|---|
| | | | | | | |

Which numbers can you scratch with your finger nail? ________________________

Which with a piece of steel or glass? ____________________________________________

**Cleavage; and crystalline or amorphous form.**

Many minerals break more readily in certain directions than in others, thus giving these minerals the property of *cleavage.* The smooth planes along which these breaks occur are called *cleavage planes.* In other directions the mineral breaks with a rough or uneven surface.

Not all smooth faces seen in minerals are cleavage planes. If a mineral is built up under proper conditions, and is free to grow in all directions, it takes a definite form known as its *crystal form.* Such minerals have smooth outside faces, called *crystal faces.*

Cleavage planes and crystal faces can be distinguished by the fact that cleavage planes repeat themselves, one parallel to the other, while crystal faces simply bound the outside of the crystal.

If the proper conditions are not present when a mineral is forming, it will not become a crystal but will appear as a lump of the substance without definite form. Such a mineral is said to be amorphous, a word meaning "without form." Minerals in the amorphous state have neither crystal faces nor cleavage planes.

**Resumé.**

Minerals are either *crystalline* or *amorphous.* Complete crystals of minerals have smooth crystal faces. Parts of crystals may or may not show smooth cleavage planes. The presence of a cleavage plane indicates that the mineral will split in that direction, with a smooth face, as finely as it can be divided. Not all crystalline minerals have cleavage planes, while some have them in a number of directions. Amorphous minerals have *no* smooth faces.

**Observations on crystal faces and cleavage planes.**

Which of your specimens have crystal faces or crystal form? ________________________ Which have cleavage planes? ______________________________________ Which have cleavage planes in more than one direction? __________________________ How many of them have cleavages at right angles to each other? ____________________________________________ How many at inclined angles to each other? ____________________________________________ Which of your specimens are amorphous? ____________________________________________

**Suggested home work for students.**

*Growing crystals.* — Dissolve as much salt as possible in a glass of hot water. Suspend a cotton string so that its free end will extend below the surface of the solution. Allow the solution to cool as slowly as possible. Note the results. ____________________________________________________________

____________________________________________________________

____________________________________________________________

Try this also with a solution of sugar. Of alum. Is there any difference in the form of the crystals? ______ Try the effect of cooling a salt solution rapidly. ______

______

______

______ Make a cold solution of either sugar or alum and allow it to evaporate slowly. Why should these crystals be so much larger and more perfect than the others? ______

______

______

______

______

**Luster.** The manner in which light is reflected from a mineral gives it an appearance that is termed its *luster*. Thus from some minerals the light is reflected so that it appears like a glassy surface. Such a mineral is said to have a glassy luster. Others have pearly, metallic, oily, earthy, etc., lusters. Describe in these terms the luster of each of your specimens, and set down in the table.

| Specimen Number | Luster | Name of Specimen |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Have the teacher tell you the name of each of your specimens and set it down in the third column above, opposite its number.

**Acid test.** Apply a drop of acid to each of your specimens. If any of them begin to bubble, you have a chemical reaction; that is, the mineral is changed by the acid. Which of the minerals shows such a reaction? ______

## XV. — COMMON ROCK-FORMING MINERALS

Materials. **For Each Student. — Specimens of quartz, orthoclase feldspar, plagioclase feldspar, muscovite mica, biotite mica, hornblende, iron pyrites or pyrite, calcite, dolomite. Steel scratcher.**

**For General Class Use. — If possible have large crystal specimens of the different minerals named above for examination by the class. Hydrochloric acid and stirring rods.**

Purpose. *To learn the properties of the common rock-forming minerals.*

Introductory. On the following page is a table with a column for each specimen named above. Determine the characteristics of each mineral and set down your observations in the proper place, as indicated. The chemical composition of each is given by its chemical symbol and is also (in general terms) written out. The teacher will describe those elements mentioned with which you are not familiar. These minerals are the ones which make up the bulk of the rock masses of the earth. Hardness is to be stated in terms of *harder than steel, harder than a finger nail, softer than a finger nail.*

How many of the minerals have oxygen? ........................ How many have silicon? ........................ What does this indicate as to the abundance of these elements in the earth's crust? ................................................................ ................................ How many different elements are present in all the minerals in your list? ......................

| Mineral | Color | Hardness | Crystal Faces and How Many | Cleavage and in what Directions | Luster | Acid Test |
|---|---|---|---|---|---|---|
| Quartz ($SiO_2$) (Silicon, Oxygen) | | | | | | |
| [1] Orthoclase Feldspar ($KAlSi_3O_8$) (Potassium, Aluminum, Silicon, Oxygen) | | | | | | |
| [1] Plagioclase Feldspar [$(NaAlSi_3O_8)+(CaAl_2Si_2O_8)$] (Sodium, Aluminum, Silicon, Oxygen, Calcium) | | | | | | |
| [2] Muscovite Mica [$H_2(K.Na)Al_3(SiO_4)_3$] (Hydrogen, Potassium, Sodium, Aluminum, Silicon) | | | | | | |
| [2] Biotite Mica [$(H\cdot K)_2(Mg\cdot Fe)_2\,Al_2\,(SiO_4)_3$] (Hydrogen, Potassium, Magnesium, Iron, Aluminum, Silicon, Oxygen) | | | | | | |
| Hornblende [$(Ca(Mg.Fe)_3(SiO_3)_4\cdot Al_2O_3)$] (Calcium, Magnesium, Iron, Silicon, Oxygen, Aluminum) | | | | | | |
| Pyrite ($FeS_2$) (Iron, Sulphur) | | | | | | |
| Calcite ($CaCO_3$) (Calcium, Carbon, Oxygen) | | | | | | |
| Dolomite [$CaMg(CO_3)_2$] (Calcium, Magnesium, Carbon, Oxygen) | | | | | | |

[1] Orthoclase and Plagioclase differ in that the latter has the elements Sodium and Calcium instead of Potassium.
[2] Muscovite and Biotite differ in that the Biotite has Magnesium and Iron added to the elements composing Muscovite, while Sodium is lacking.

## XVI. — SOME OF THE MOST COMMON ECONOMIC MINERALS

**Materials.** **For Each Student. — Specimens of hematite, magnetite, halite, gypsum. Steel scratcher.**

**For General Class Use. — If possible, some specimens of limonite, magnetite, gold, silver, copper, lead, and zinc ores. (In some localities the teacher may find it desirable to have these minerals for each student.) Hydrochloric acid and glass stirring rods.**

**Purpose.** *To learn the characteristics of a few important economic minerals.*

**Method and results.** Make observations and describe each of the above minerals; putting the description of each in the form of a sentence, as below.

Hematite (Fe and O) has a ______________________ color; a hardness ______________________

________________________ ; ________________________________________________crystal faces are

(or are not) present; ____________________________________________ cleavage planes are (or are

not) present; these are at ____________________________________________ angles to each other;

its luster is ______________________; and it does (or does not) respond to the acid test. It

is used as a source of ____________________________________________________________

______________________________________________________________________________

Magnetite (FeO) ____________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Halite (NaCl) (Cl = Chlorine) ____________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Gypsum ($CaSO_4 + H_2O$)

Examine the specimens (if any) which the teacher distributes and set down the most striking characteristic of each.

## XVII.—COMPARISON OF CHARACTERISTICS OF COMMON MINERALS

**Materials.** **For Each Student.**—The specimens of the rock-forming and economic minerals previously studied.

**Purpose.** *To learn to distinguish between minerals having similar properties.*

Refer to the table of properties you have already made, and reëxamine the specimens.

**Comparison of minerals.** In what characteristics do quartz and feldspar resemble each other? ____________________

______________________________________________________________________

______________________________________________________ How can they be told apart? ______________________________________________________________

______________________________________________________________________

__________________________ Examine the cleavage faces of the orthoclase and the plagioclase feldspar. Which kind has the fine parallel lines? ______________________________________

How do the two micas differ in color? ________________________________________

__________________________________ Would the fact that iron is present in the biotite suggest any explanation for this? ______________________________________________

__________________________ In what properties does hornblende resemble the feldspars?

______________________________________________________________________

_____________________________________ In which does it differ? ____________________

______________________________________________________________________

____________________ Is its cleavage as easy to see as that of the feldspars? ________________

How may hornblende and mica be distinguished? ______________________________________

______________________________________________________________________

How would you most quickly recognize pyrite? ________________________________________

_____________________________________ What resemblances have calcite and dolomite?

______________________________________________________________________

______________________________________________________________________

How may they be distinguished from each other? ________________________________________

________________________________________ In what ways does halite resemble quartz?

________________________________________________________________________________

Taste both. What is the result? ________________________________________

________________________________ What would happen to halite if it were present near the surface of the earth in a humid climate? ________________________________________

________________________________________________________________________________

How could you most readily identify hematite? ________________________________________

________________________________________ What is the most noticeable property of gypsum? ________________________________________

________________________________________________

## XVIII. — GENERAL CLASSIFICATION OF ROCKS

**Materials.** **For Each Student. — Specimen of granite, sandstone, fossiliferous limestone, schist. Fine-pointed steel scratcher, or knife point.**

**For General Class Use. — Hydrochloric acid and glass stirring rods.**

**Purpose.** *To learn the characteristics of the four great classes of rocks.*

**Igneous rocks.** Examine your specimen of *granite*. Of how many different minerals is it composed?

______________________ Are the minerals crystalline or amorphous? ______________________
Identify each mineral, and make a list of them in the order of importance as to amount present.

________________________________________________________________________________

________________________________________________________________________________

How are the minerals arranged with respect to one another? ____________________________

________________________________________________________________________________

________________________________________________________________________________

This kind of rock is known as an *Igneous* (= Fire) *Rock* because of the fact that it is formed by the cooling of a hot molten mass of rock magma which rises from within the earth. If such a molten mass *cools slowly*, the minerals can separate out into crystal grains of good size, as in the granite you have examined; if they cool very quickly, the rock which results is like a black glass, or furnace slag. There are all gradations between these two extremes. Then again, the molten magmas are of different composition; some have elements that others lack. Consequently, minerals that are present in one igneous rock may be absent in others.

**Sedimentary rocks.** What mineral composes the bulk of your sandstone specimen? ______________________

Are other minerals visible? ______________ If so, what proportion of the mass do they form?

________________________________________________________________________________

Rub your finger (or a knife) with some pressure over the surface of the specimen. What is the shape of the particles you break off? ________________________________________________

________________________________________________________________________________

____________________________________ What differences do you see between the sandstone and the granite? ________________________________________________________________

________________________________________________________________________________

Sandstone is a *Sedimentary Rock;* that is, it is one of the great class of rocks which are formed by deposition, generally in water. The material, or *sediment*, of which they are composed, is usually brought by streams which have gathered it along their courses and carried it in their currents to their mouths, where they must deposit it, because the current ceases. Sedimentary rocks are all alike in the fact that they have been formed by deposit from a current, usually a water current; but wind, for example, may also act as a carrier and depositor of sediment.

**Organic rocks.**

What traces of animal life does your limestone specimen show? ____________________

Where do such animals live? ____________________

What becomes of their shells when they die? ____________________

Does the acid affect this rock? ______________ How might such a rock be formed? ____________________

Limestone such as this is an *Organic Rock.* Organic limestones, however, grade into those which have formed chemically (as a deposit of salt would form in a glass if you dried up a salt solution). When limestones are chemically formed, they are generally classed with the sedimentary rocks.

**Metamorphic rocks.**

Of what minerals is your schist specimen composed? ____________________

How are these arranged? ____________________

How does this affect the rock's strength? ____________________

Why is it not as strong as a granite? ____________________

Along the lines of what mineral does it break most readily? ______________________________

______________. Why? ______________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

Schist is one of the great class of *Metamorphic* (changed) *Rocks*. Originally they were igneous, sedimentary, or organic rocks; but later they were heated and compressed in the earth's crust, so that they have acquired altogether different characteristics than they had originally. Such a change in rocks is called metamorphism.

Does solid rock appear at the surface anywhere near your home? ________________ To which of these four classes of rocks does it belong? ______________________________________

At the next period bring a specimen from the rock outcrop.

## XIX. — CLASSIFICATION OF IGNEOUS ROCKS

**Materials.** **For Each Student. — A specimen of pumice, cellular lava, obsidian, rhyolite, granite, trachyte, syenite, gabbro, basalt.**

**For General Class Use. — Small pieces of rock, unlabeled.**

**Purpose.** *To become familiar with the general types of igneous rocks, and the characteristics by which they are distinguished.*

**Steam a cause of porous lavas.** When water is boiling, in what form does the steam rise from the bottom of the vessel to the surface? ________________ What is meant when we say that the liquid which is boiling "froths over"? ________________

________________

If this "froth" were hardened just as it rises over the rim of the vessel, what would be the appearance of the mass formed? ________________

________________

________________

If molten rock were being "frothed over," or blown out of the crater of a volcano by the steam and gases that rise from it (see Fig. 203, Text-book), what would be the nature of the rock that is formed on its cooling? ________________

________________ Which of your specimens shows evidence of having had such a history? ________________ Which one shows evidence of less violent steam action? ________________

**Classification by texture.** If the molten rock flowed over the volcano rim very quietly (like molasses candy being poured from a kettle), and then cooled quickly, which of your specimens do you think it would most resemble? ________________ If there were *no* steam or gas in the lava, which specimen would result? ________________

Why is artificial glass similar in appearance to this specimen? ________________

________________

________________

Find the specimen which you think has cooled a little more slowly than the obsidian.

---------------------------------------------------------------------------------------

What specimens give evidence of the following condition of cooling: First, the lava cooled slowly for a time, at a rate which permitted some of the minerals to separate out and form visible crystals; then it cooled rapidly and the rest of the mass made a rock of fine texture?

---------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------

What minerals have separated out in your specimens of these (*porphyritic*) rocks? ----------

---------------------------------------------------------------------------------------

Which rocks formed in the places indicated in Fig. 12 would cool rapidly? ------------------

---------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------

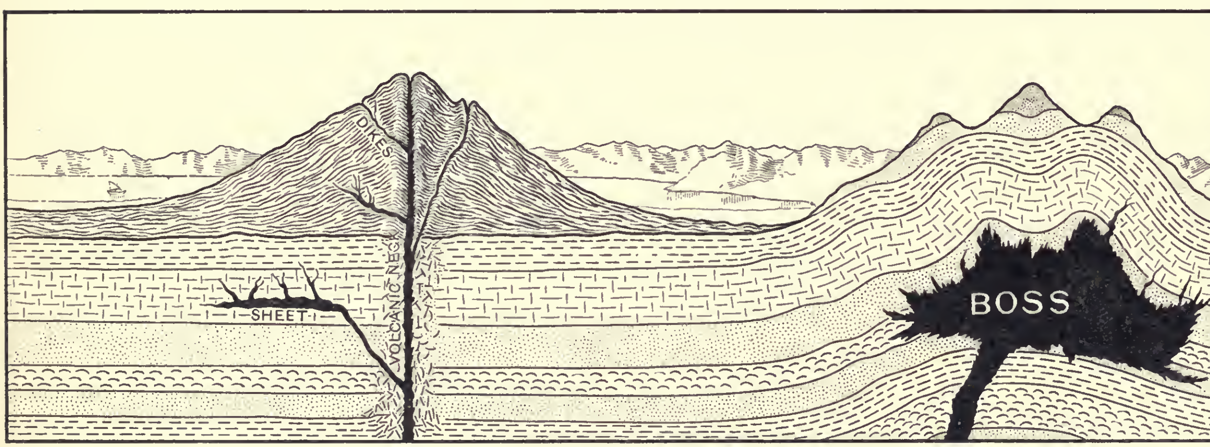

FIG. 12. — TO ILLUSTRATE THE ORIGIN OF IGNEOUS ROCKS.

Would this give rise to coarse or fine grained rocks? ------------------------------------

In what position would such rocks as granite, syenite, and gabbro be formed? ---------------

---------------------------------------------------------------------------------------

The observations you have made above give a basis for a classification of igneous rocks by *structure*, or *texture*. Pumice, obsidian, and some other lavas are *glasses*. Rhyolite and trachyte are porphyries. Basalt is a *finely crystalline* igneous rock. Granite, syenite, and gabbro are *coarsely crystalline* igneous rocks.

**Classification by composition.**

The glasses cannot be further subdivided (because they are too fine grained); but all the other rocks are also grouped according to their *composition*.

Refer to your table of the properties of minerals. Which minerals are light in color?

Which are dark ?

In which of these two groups are the minerals which have the most *metallic* elements (iron, magnesium, calcium, sodium, and potassium) ?

Which is the darker, orthoclase or plagioclase feldspar ? Which has the most metals in its composition ? What do you observe as to the relation between color of mineral and the presence of metallic elements ?

Arrange all your specimens (except the glasses) in a row, putting those lightest in color at the left-hand side. Write down the order in which you have arranged them.

What sort of a rough grouping have you now made of the rocks ?

Now make two rows of your specimens, putting the porphyries and basalts in the lower row, but still keeping the specimens in the same order as to color. Write down the order of the specimens in each row.

Examine your *granite* specimen (which should be first in the upper row). What minerals does it contain (look very carefully)? ______________________________________________

______________________________________ Examine the *syenite* (the next in order). What prominent mineral of the granite does it lack? ______________________ Which kind of feldspar has it? ______________________ Examine the *gabbro*. Which kind of feldspar has it? ______________________ What other minerals does the gabbro contain? ____________

______________________________________________________________________________

______________________________________________________________________________

A rock is said to be *acid* when it is made up mainly of the *light-colored* minerals, which have the *lesser amounts* of the metal elements. The rocks in which the minerals have metallic elements are said to be *basic*. Thus quartz is the most acid, and pyrite the most basic of those rock-forming minerals that you have studied. Which of the rocks in your collection are acid? ______________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Which basic? __________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Whether a rock is acid or basic gives a basis for a second method of classifying igneous rocks; namely, a classification according to composition. In the following table write in the names of each of your specimens, keeping in mind the two kinds of classification: — (1) composition; (2) texture.

| | ACID END ⟶ ⟵ BASIC END | | |
|---|---|---|---|
| | Has quartz and orthoclase feldspar | Orthoclase feldspar but no quartz | Has plagioclase feldspar and other basic minerals |
| Coarsely Crystalline | | | |
| Finely Crystalline | | | Basalt |
| Porphyries | | | |
| Glasses | | | |

By means of this table identify the specimen you have collected from the home locality if it belongs among the Igneous Rocks. Identify the small pieces of rock given you by the teacher, telling (*a*) the minerals in each ; (*b*) whether acid or basic ; (*c*) its texture ; (*d*) its name.

## XX. — CLASSIFICATION OF SEDIMENTARY, ORGANIC, AND METAMORPHIC ROCKS

**Materials.** **For Each Student. — Specimens of conglomerate, sandstone, shale, limestone, coal, gneiss, schist, quartzite, slate, marble.**

**For General Class Use. — Hydrochloric acid and glass stirring rods. Small pieces of rock, unnamed.**

**Purpose.** *To become familiar with the more common types of these classes of rocks, and to learn how to distinguish between them.*

**Sedimentary and organic rocks.** Assume a stream flowing into the sea and carrying along in its current small pebbles, sand grains, and clay particles. It also has carbonate of lime in solution. All this material the stream has secured along its course by the breaking up of some kind of rock, through the action of the agents of weathering and erosion.

When such a stream empties into the ocean, will its current continue unchecked in velocity? ______________________ Will the current continue at all for any great distance from the shore? ________________ What then will become of the rock material that the current is carrying? ____________________________________________________________ ______________________ Which part of the load that the current carries will be deposited first? ____________________________________________ Why? ____________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

______________________________________________ Which of your specimens is formed of such materials? ______________________________________________ Which kind of material will be deposited a little farther out from the shore? ________________________________________ What kind of rock does this make? ______________________ Which of your specimens might result from the deposit of the clay particles? __________________________________________ Which of your specimens might have resulted from the deposit of the lime solution? ______________________________________________ How might the sea animals, whose traces are shown in your limestone, aid in its formation? ________________________________________

__________________________________________________________________________________________

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Would there be a sharp line between the place of deposit of sandstone and conglomerate?

_______________ Between the sandstone and the shale? _______________ Draw a diagram illustrating deposit of sediment in the sea to show how variation in texture would occur from the shore outwards.

Limestone is often formed from the remains of lime-secreting animals. Plant remains also form organic rocks. Coal is such an organic rock formed of plant remains accumulated in ancient swamps. Are there any traces of plants left in your specimen? _______________ How could you test whether a black rock was coal? _______________

In what ways do sandstone and limestone differ? _______________

---

---

_______________ Shale and limestone (use acid test)?

---

---

Shale and sandstone? _______________

---

---

________________________ Sandstone and conglomerate? ____________________________________

______________________________________________________________________________________

__________________________________________________________

Identify the unlabeled specimens.

**Metamorphic rocks.** By means of the acid test find which of your metamorphic specimens was changed from a limestone. ______________________________________________ Compare it with limestone and note the nature of the change. ______________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

______________________________ Which of the metamorphic rocks most nearly resembles shale? ________________________ How does it differ from shale? __________________________________

______________________________________________________________________________________

______________________________________________________________ Micaceous minerals are abundantly present in slate, and you may be able to see them in your specimen. Why would the presence of such minerals cause the slate to split so regularly? ____________________________

______________________________________________________________________________________

______________________________________________________________________________________

__________________________________________________________________ What two specimens have been so metamorphosed as to resemble the igneous rocks? ________________________________

________________ Assuming both these to have been originally clay rocks, which has apparently been changed most? ________________________________________________ What is the arrangement of like minerals in each? ________________________________________________

________________________________ Why is it easier to split the schist than the gneiss?

________________________________________________________________________________

________________________________________________________________________________

What metamorphic specimen is yet unclassified? ______________________ From what is this derived? ____________________________________________ How has it been changed?

________________________________________________________________________________

________________________________________________________________________________

Identify the unlabeled specimens. If the specimen of rock from your home locality was not an igneous rock, identify it among the sedimentary, organic, or metamorphic rocks.

________________________________________________________________________________

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## XXI. — THE SOIL

**Materials.** **For Each Student. — Specimen of rock with lichen attached. Several rounded stream pebbles. Residual soil from granite. Residual clay from limestone. Field soil secured from beneath sod. Small fragment of limestone. Hydrochloric acid. Test tube. Glass plate.**

**For General Class Use. — Hand specimens of minerals and rocks.**

**Purpose.** *To study the origin and nature of soils and their significance to man.*

**Origin of soil.** From your study of minerals, what few make up the larger part of the rock masses of the earth's crust? ____________________

____________ Which of these minerals have cleavage planes? ____________

____________ If you poured water over minerals, some with cleavage planes and some without, which ones would absorb the water most readily? ____________

____________ What would happen if the water-soaked minerals were to freeze? ____________

____________ How would a rock composed of cleavable minerals be affected if first soaked by rain, and then exposed to a freezing temperature? ____________

____________________

____________

When the mercury in a thermometer tube is heated, why does it rise? ____________

____________ Most substances have this property, but the amount of expansion for the same degree of heat is different for different substances. Thus different minerals expand different amounts under the same heat. What would be the effect on the rock itself if the minerals in a granite expanded at different rates? ____________

____________________

If you put salt in water, what happens? ____________

If you put acid on limestone, what happens? ____________
Other acids have a similar effect. Rain water obtains carbon dioxide from the air and from plant remains. The combination of the water and carbon dioxide forms carbonic acid. When

this acid soaks down to the soluble limestone, what will happen? ________________________

________________________________________________________________

Examine the rock specimen with the lichen growing on it. By what means does the plant cling to the rock? ________________________________________________________________

________________________ If its roots grow after penetrating a tiny crevice in the rock, what will be the effect of their growth on the rock? ________________________________________________

________________________________________________

State clearly the general effects of these weathering agents on all minerals and rocks exposed to the air. ________________________________________________________________

________________________________________________________________________________________________

__________________ Have all minerals cleavage planes? ________________ Are all minerals dissolved by acid? ________________ Are all rocks made up of the same amounts, or of the same kinds of minerals? ________________ What bearing have these differences on the rate at which different rocks are broken down? ________________________________________________

________________________________________________________________________________________________

________________________________________________________________________________________________

________________________________________ Why is almost all the earth's surface covered with "dirt," sand, and clay, while bedrock is seen only occasionally? __________________________

________________________________________________________________________________________________

________________________________________________________________

Examine the stream pebbles. Have they sharp edges and corners? ________________ What has happened to the pebbles since they were broken off from the bedrock?

________________________________________________________________________________________________

________________________________________________________________________________________________

What becomes of the particles which are ground off? ________________________________________

________________________________________________________ What kind of deposits do they form in stream beds? ________________________________________________________________

________________________________________________________________________________________________

**Residual soils.**

Examine the residual soil from granite by spreading a small portion on your glass plate. What mineral of the granite has remained unaltered? ______________________ What mineral composes the greater mass in a granite rock? ______________________________________________

What material seems most abundant in this residual soil of granite? ________________________

What has happened to the feldspar of the granite? ________________________________________

Put a small fragment of limestone in a test tube half full of hydrochloric acid. What happens? ________________________________________ What sort of material remains in the test tube after the bubbling ceases? ________________________________________ ________________________________________ Examine the residual clay from the limestone. How does it differ in composition from the residual material of granite? ________________ ________________________________________________________________ ________________________________________________________________ ________________________________________________________________ Why is there this difference? ________________________________________________________ ________________________________________________________________ ________________________________________________________________ ________________________________________________________________ ________________________________________________________________ ________________ The original limestone rock from which the clay has been derived may be gray, brown, or black. What is the color of the residual clay? ________________________ ______________________ To what is the color due? ________________________________________

What material of the limestone rock remains behind as residual clay? ____________________ ________________________________________________________ Which rock would give the greater amount of residual material, granite or limestone? ______________________

Why? ________________________________________________________________ ________________________________________________________________ ________________________________________________________________

il. Examine the sample of field soil. How does it differ in appearance from the pure residual soils? ..............................................................................................

..............................................................................................

..............................................................................................

..............................................................................................

Put a small portion of the soil in a test tube $\frac{2}{3}$ full of water; shake, and then allow to settle. What kind of material floats? .............................................. What is the source of the organic matter? ..............................................................................................

.............................. What part of the soil remains suspended for a long time?

.............................................. What material quickly settles to the bottom?

.............................................. How does the field soil differ in composition from the pure residual soils? ..............................................................................................

..............................................................................................

..............................................................................................

..............................

What is the effect of the presence of plant roots on the texture of the field soil?

.............................................. The presence of organic matter, and the greater porosity of field soils, gives them fertility and enables them to support plant life. The subsoil, in which plants have never grown, is quite infertile. Why then would it be unwise to plow up soil below the depth to which plant roots usually penetrate?

..............................................................................................

Why are manures placed on poor soils? ..............................................................................................

..............................................................................................

.............................................. Where do growing plants secure their water?

..............................................................................................

Will plants grow well in a very compact soil? (See suggested home experiment.)

................ What is the effect of plowing the soil? ..................................

..........................................................

What kinds of food do cattle eat? ________ What kinds of food does man eat? ________ Traced back to its original source, what is the real basis of supply of food for man? ________ State clearly the importance of soil to the life of human beings. ________

**Suggested home or general class work.**

Secure four pans about three inches deep and eight inches long. Into two of these put clayey field soil, loosely, and in each, during the process of filling, plant 20 grains of corn at a depth of one inch. Keep one of these pans moderately moist, the other very wet, and let both stand in a warm place.

Into the remaining two pans put the same kind of field soil, but pack it very firmly; and, during the process of filling, plant 20 grains of corn in each at a depth of one inch. Keep one of these moderately moist, the other very wet. After ten days observe how many plants are growing in each pan. Under which treatment did the greatest number of seeds grow? ________ The least? ________ What was the effect of the different treatments of the soils on the entrance of air between the soil grains? ________ What is the effect on plant life of preventing the entrance of air into the soil? ________ Give a reason why fields are plowed. ________ Why a field should be drained of its surplus water. ________

SCALE.

FIG. 13. — CONTOUR INTERVAL.

# MAKING AND INTERPRETATION OF TOPOGRAPHIC MAPS

## XXII. — CONSTRUCTION OF AN AREAL MAP

(With tank and land model, see page viii)

**Materials.** **For Each Student. — Ruler. Pencil (well sharpened).**
**For General Class Use. — Land model and tank. Yardsticks.**

**Purpose.** *To make an areal map of a miniature land form.*

**Scale.** What is the length of the platform on which the land model rests? ____________________

What is its width? ____________________ What is the length of the accompanying sheet of paper (Fig. 13)? ____________________ Its width? ____________________ If your platform were five feet long and four feet wide, and your paper ten inches long and eight inches wide, what would be the greatest amount of space that you could allow for every foot of the platform, if you were asked to draw an outline of the shape of the platform on your paper?

________________________________________ What explanation would you need to put on such a drawing so that others could understand what the size of the original was? ______

________________________________________ What is meant by the *scale* of a drawing or map? ________________________________________

________________________________________

________________________________________ Why would it be more convenient to adopt a scale one half that of the largest possible scale for drawing the 5 × 4 foot platform on paper 10 inches by 8 inches in size? ________________________________________

________________________ What does the phrase 1 inch = 1 mile (printed on many maps) signify?

________________________________________

________________________________________

__________ From your measurements of your own platform and paper, decide what will be the most convenient scale for you to adopt for the map you are to make, and write it down opposite the word "scale" on the sheet of paper (Fig. 13).

**Orientation** Turn your drawing paper so that the arrow printed on the sheet points to the north. Mark an *N* above it. Mark *S* for south, and *E* and *W* at the proper ends of the other lines.

Which side of the model will you draw on the north side of your map? ________________

________________________ Holding a map so that its directions correspond with the actual directions is called "orienting" the map. Why should this be done, whenever possible, when using a map of any kind ? ________________________________________

________________________________________________________________

**Areal mapping.** Draw an outline of the platform according to the scale you have adopted. Then beginning on the side assigned by the teacher (different members of the class begin on different sides), measure with the yardstick the distance from the edge of the platform to different points where the water touches the land model (as *a–b*, Fig. 14). Measure only to the prominent points, such as the ends of the capes, the heads of the bays, etc. Measure also, each time, the

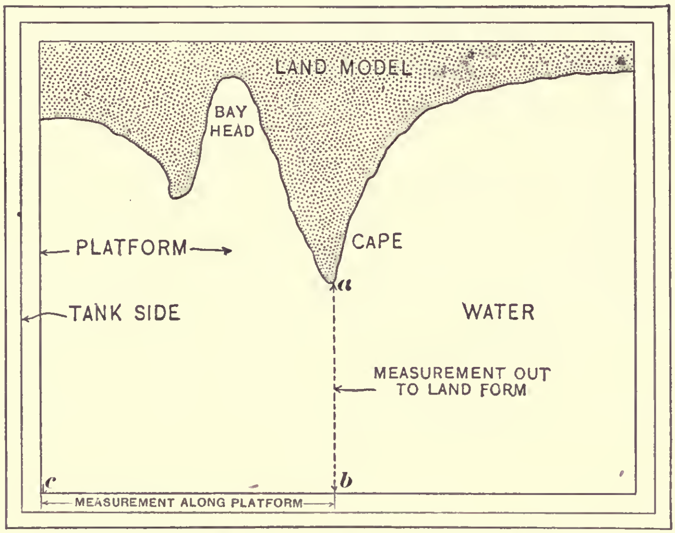


FIG. 14. — DIAGRAM TO SHOW METHOD OF MAKING MEASUREMENTS FOR AREAL MAP.

distance from a corner of the platform along the edge of the platform to the point from which you measure out to the land model. These two measurements are diagrammed in Fig. 14 as *a–b* and *b–c*.

Then, in the same way, locate the position of the highest points of mountains, and mark these on your map by little triangles ( = △ ). Next, locate the course of the main streams (as indicated by blue yarn on the model), and trace a line on the map to show each of these. Locate other points as indicated by the teacher.

The work you have done so far is similar to the work that topographers do when making an *areal* map of a similar island in nature, except that in actual land mapping you would measure with instruments from point to point on the island. Also, you would need to locate more points. Areal mapping means locating the position of prominent points, streams, roads, etc., in a given area, with reference to each other and to the *cardinal* directions; and also determining their latitude and longitude. Could you tell the *height* of a mountain from such an

areal map ? ________________ Could you tell whether a mountain had a steep *slope* on one

side or a gentle slope on the other ? ________________ Could you determine the *form* of a

mountain ridge ? ________________ What two features shown on the model are not expressed

on the map as you have made it up to this point ? ________________________________

________________________________________________________________

## XXIII. — CONSTRUCTION OF A CONTOUR MAP

**Materials.** **For Each Student. — Ruler and brown pencil, well sharpened.**

**For General Class Use. — The model used in the previous exercise [and if plaster model is used, a number of boards of uniform thickness as directed on page ix of this manual].**

**Purpose.** *To express the relief features of a miniature land form on a map by means of contour lines.*

**Base level, or datum plane.** What line on the areal map that you have drawn (Fig. 13) shows the contact of water and land? ____________________

What is its level, with reference to the water surface? ____________________

____________________ What kind of surface has a body of standing water? ____________________ Why are all elevations on the earth's surface expressed by their height in feet (or meters) above sea level?

____________________

Why is the mean (or average) sea level often referred to as the *datum plane*, or *base level ?*

____________________

____________________

____________________

**Contour interval.** The water in the tank may be considered as a miniature sea.

What is the elevation of any point along the outline of the map you have drawn, with reference to this sea level, or datum plane? ____________________

____________________ Lower the model and its platform a certain depth into the water, equally on all sides. How much did you lower it? ____________________

Has the water level changed? ____________ Where does the water surface come into contact with the land now? (Express in general terms.) ____________________

____________________

____________________

Draw (with brown pencil, on Fig. 13) the new outline of the contact of the land surface and the water (making measurements and plotting, as done previously on the areal map you have made). Does this new outline come outside or inside the original outline?

If now the model were lifted back to its original position with reference to the water level, and a path were traced around the model in the position fixed by the second outline, would this path go uphill, remain always at the same level, or go downhill?

What then is the relation of the second outline to the first outline?

Such a line, drawn on a map through all points at the same elevation above sea level, is known as a *contour line*. Why should the difference in elevation between the sea level and the contour line you have drawn be known as a *contour interval?*

**Contour lines and slope.** Does the contour line that you have drawn extend farthest in from the sea-level line at points where the slope of the model is steep or gentle?

**Succeeding contours.** Lower the model again, the same distance as the first time. Locate and plot the new contour line. What is the contour interval you have adopted?

Write it down on the line opposite the words "Contour Interval" printed on your map (Fig. 13). Number your contour lines on the map to show what elevation above the original sea level they represent. Lower the model equal distances until the highest points are submerged, and draw the contour lines for each interval. What is the form of the contour line showing the highest elevation of the mountain?

How do the contour lines bend when they enter a valley?

When they come to a headland?

Where are they farthest apart, on steep or gentle slopes?

What reason can you give for using a brown pencil in drawing the contour lines?

**Use of a contour map.** What does a contour map show that the areal map did not?

Why are such maps

called *topographic* maps? ______________________________________________

______________________ Why would a topographic map be much more useful than a simple areal map to a man who wished to make a road between two points? ____________

________________________________________________________________

________________________________________________________________

How could one find out from a topographic map how many feet a river descended from its source to its mouth? ______________________________________________

## XXIV.—MAKING A CROSS SECTION OF A CONTOUR MAP

Materials. **For Each Student.—Ruler. Sharp pencil. Sheets of plain paper.**

Purpose. *To teach the making of cross sections from contour maps.*


Fig. 15.—Contour Map of Miniature Land Form made by a Student in Physical Geography.

**Study of a simple contour map.** Figure 15 is a contour map of a miniature land form made by a student in physical geography.

What is the scale of this map? ______________________________

What is the contour interval? ________________ How can you tell which slopes on the land form were steep and which were gentle? ________________

________________

________________ On which sides of the miniature land form were the shores steep? ________________

________________ On which sides did it have gentle slopes? ________________

________________ What was the highest elevation on the land form? ________________ Why was this figure printed in on the map? ________________

________________ Which contour lines are heavier than others? ________________

________________ What aid does this heavier printing of some contour lines give when reading the map? ________________

________________ By what other means are these heavier contours distinguished from the rest? ________________

On the northern side of the map, the two-inch contour line bends far inland. If you crossed the miniature land form in an east and west direction, would you find the land inside the bend higher or lower than two inches? ________________

What would be the case if the contour bent outward toward the sea? ________________

________________ Find and note an illustration of a contour line bending outward.

________________

**Meaning of cross section.**

Note the line *A–B* on the map, Fig. 15. What are the elevations of the two highest points it crosses? ________________ What is the elevation of the lowest point it crosses between these high points? ________________ Make a drawing (on Fig. 16) to show how your path would go uphill and downhill if you were to cross the land form along the line *A–B*, starting at *A*.

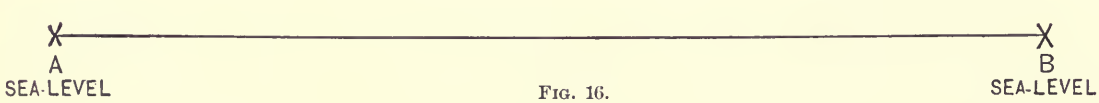


Fig. 16.

The drawing you have made is a crude *cross section* of the land form along the line *A–B*. If a cross section is accurately made from a contour map, it shows clearly, in diagram form, the elevations, depressions, and level places of the region along the line on which the cross section is made.

**Plotting intersections of contours.** To make an *accurate* cross section along the line $A$–$B$ proceed as follows: Fold a sheet of your plain paper through the middle so that you have a smooth, folded edge at least six inches long. Next lay this paper over the map so that it covers the southwest corner of the map, and

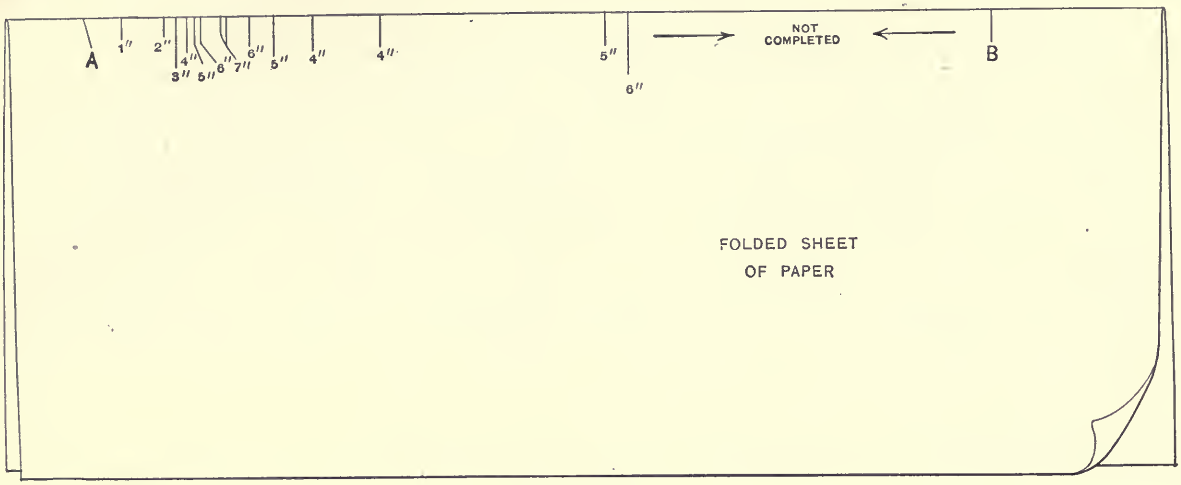


Fig. 17.

so that the folded edge rests on the line $A$–$B$, leaving this line visible. At $A$ and $B$ draw short ($\frac{1}{2}''$) vertical lines down from the folded edge of the paper, and mark $A$ and $B$, respectively, at their ends. $A$ and $B$ are each at sea level, or 0 elevation. With sharp pencil mark on the folded sheet (with similar short vertical lines) the exact point of intersection of each contour line with the folded edge. Begin at $A$ and continue to $B$. Below each vertical line indicate by a figure the elevation of the contour line whose intersection it marks. When this operation is partly completed, the edge of your folded sheet should be similar to Fig. 17.

**Plotting the intersections on cross-section paper.** On the accompanying cross-section paper (Fig. 18) draw a pencil line along one of the lower horizontal ruled lines, so that it stands out distinctly from the rest. This is to be your 0 line or sea-level, or base-level line. At the left-hand end of the zero line, draw a line perpendicular to it, and 13 small squares high. Number the horizontal lines which this perpen-

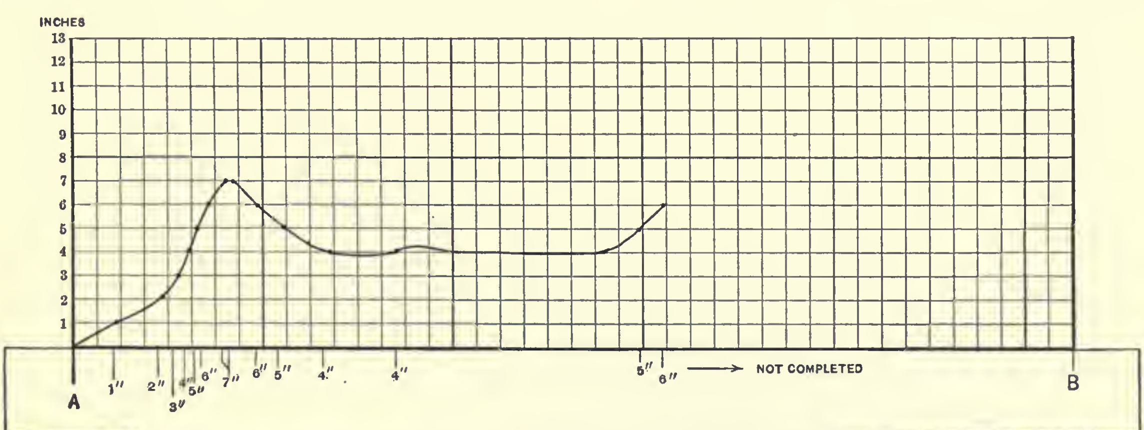


Fig. 19.—To illustrate Method of making Cross Section from Contour Map.

dicular crosses, from 1″ to 13″; the 1″ line being the one next above the zero or sea-level line. Mark this end of the drawing *A*.

Now lay the folded edge of the sheet, on which you have marked the intersections of the contours along the sea-level line, so that the point *A* on the folded edge coincides with the point *A* on the horizontal line of the cross-section paper. Next make a dot with your pencil on the 1″ horizontal line of the cross-section paper, at a point exactly above the place where you have marked the intersection of the 1″ contour line on the folded edge. For the 2″ contour intersection put a dot on the 2″ horizontal line; and so on until you have put dots on the proper horizontal lines for all the contour intersections, and have reached sea level again at *B*.

Next connect the dots by means of a smooth curved line, avoiding sharp angles. When partly drawn, your cross section should be similar to Fig. 19.

**Horizontal and vertical scale.**

The scale of the map was 1 inch = 1 foot. Therefore the horizontal scale of your cross section is the same, and you should print or write this below your cross section, thus: Horizontal Scale 1 inch = 1 foot. What is the vertical scale of your cross section? ______________

____________________________ Above the cross section, write "Cross Section, along the line *A–B* on Map, Fig. 15." Always mark the vertical and horizontal scale, and the line along which it is taken, on every cross section you make.

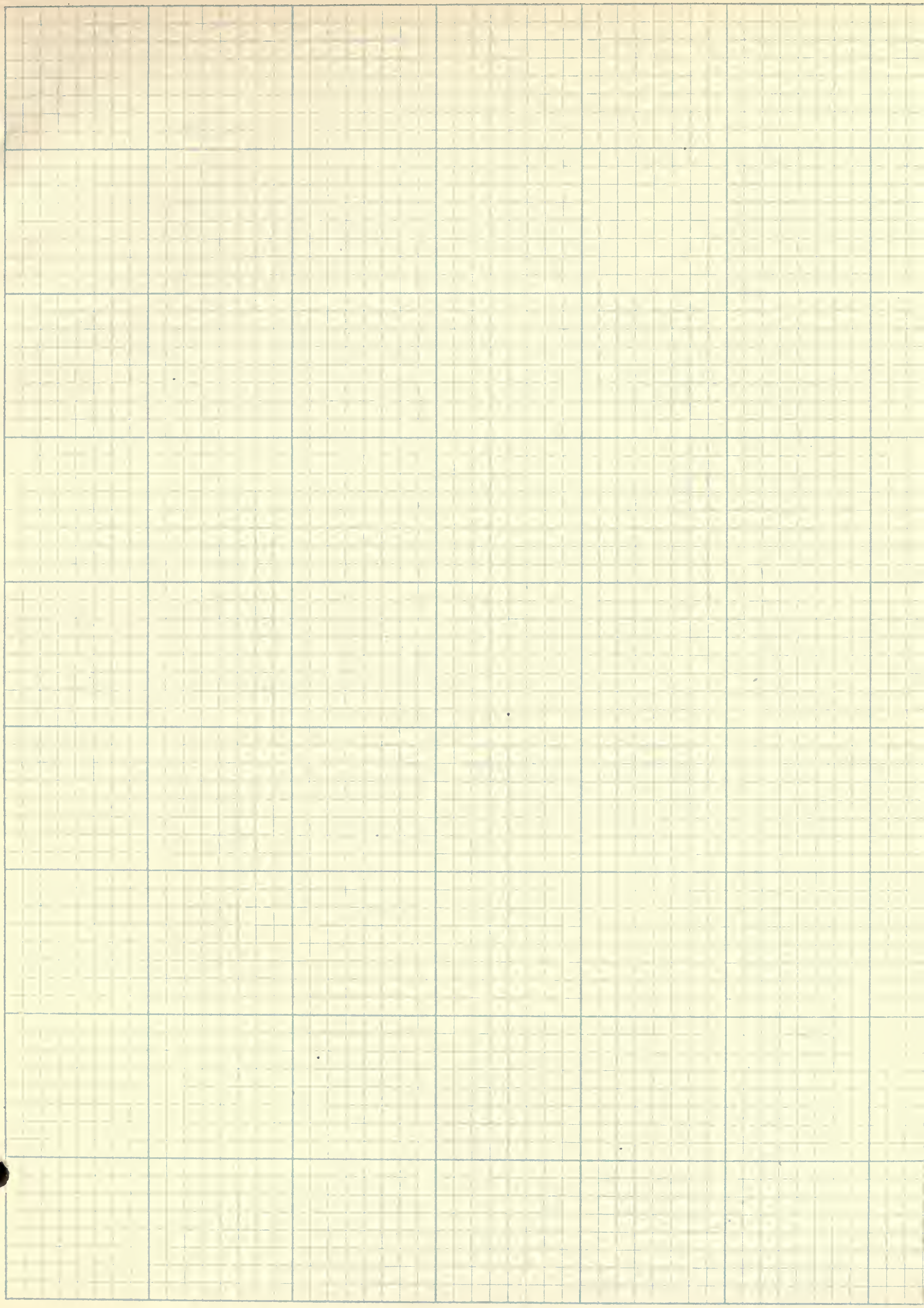

Fig. 18.

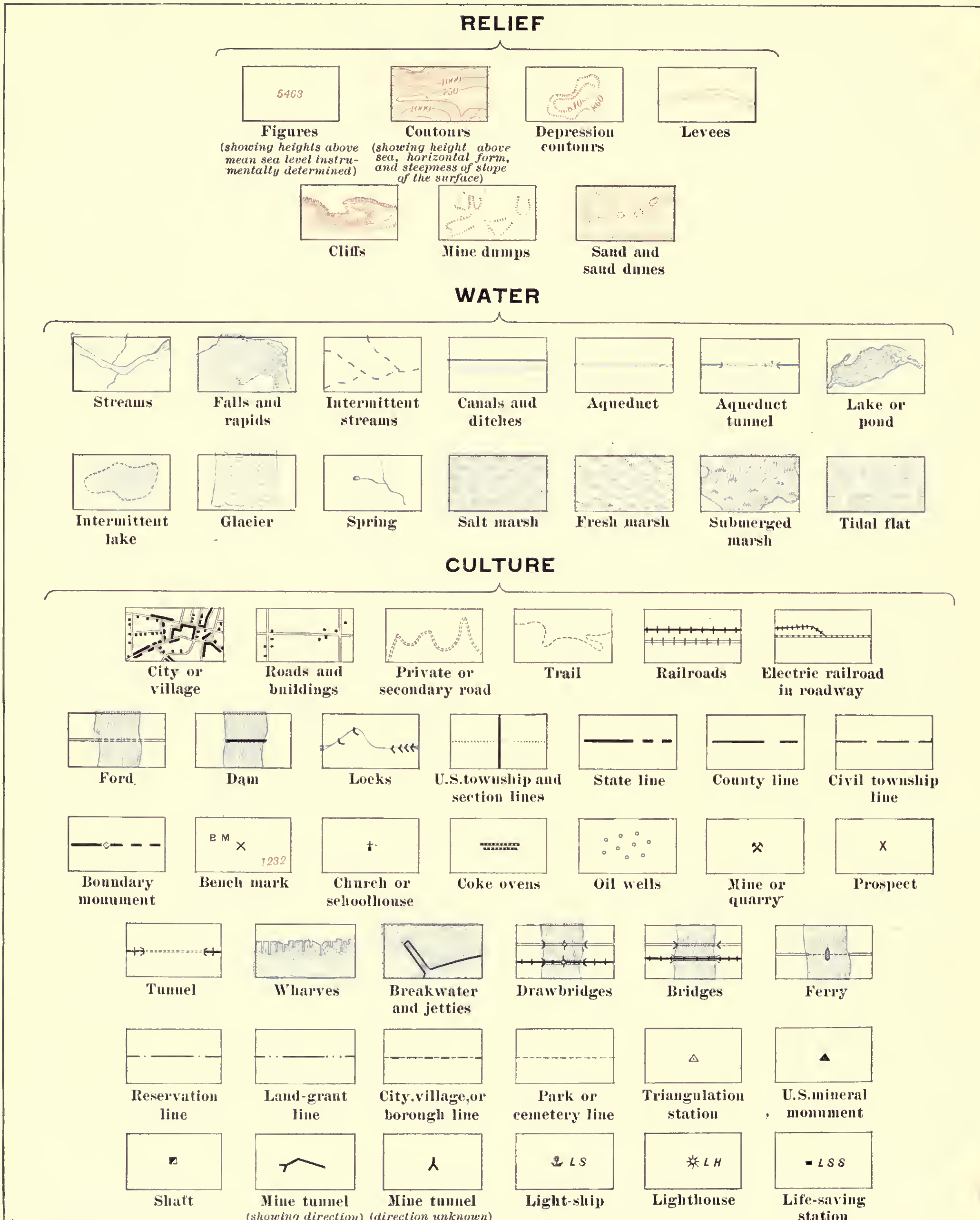


Fig. 20. — Conventional Signs used on Atlas Sheets of the United States Geological Survey's Topographic Maps.

## XXV. — MAKING A CROSS SECTION AND A STREAM PROFILE FROM A UNITED STATES TOPOGRAPHIC MAP

**Materials.** **For Each Student. — Ruler. Pencil. Several sheets of plain paper. Montross sheet. Maryland-Virginia.**

**Purpose.** *To teach the understanding of the conventional signs used on a topographic map, and the making of cross sections and profiles from such maps.*

**Conventions of a topographic map.** Figure 20 illustrates the conventional signs used on the United States Geological Survey topographic maps. What color is used for contour lines? ______________________ What is meant by *Relief?* ______________________________________________________________________

What color is used for road, county, and state lines, and for buildings and cities? __________ ______________ Why should these features be called *cultural* features? ____________________

______________________________________________________________________________

______________________________________________________________________________

What color is used to indicate water? ______________________

**Cross section of a topographic map.** Make a cross section (on accompanying sheet of cross-section paper) of part of the Montross sheet along a line between Stony Hill and Montross, proceeding as you did in making the cross section of the simple contour map in the preceding exercise. A very sharp pencil and even greater care will be necessary. In making the cross section note carefully whether you are crossing a valley or a divide between valleys.

**Exaggeration of relief in a cross section.** What is the horizontal scale of the map? ______________________________________

What is the contour interval? ______________________ What is the vertical scale of your cross section? ____________________________________ If the horizontal scale of your cross section is one inch = one mile, and your vertical scale is $\frac{1}{8}$ inch = 20 feet, how much is your vertical scale exaggerated? ____________________________________ (5280 feet = 1 mile, therefore 5280 feet = 1 inch horizontal scale. 8 x 20 = 160 feet, therefore 160 feet = 1 inch vertical scale. Therefore in the cross section 160 feet vertical scale equals 5280 feet in the horizontal scale.)

Why would it have been much better to use a vertical scale $\frac{1}{8}$ inch = 80 feet? __________

______________________________________________________________________________

Plot the same cross section on this scale. What is the exaggeration of the vertical scale in this case? ............................................. Always endeavor to avoid too great exaggerations of the vertical scale in making cross sections and profiles.

**Profile of a stream valley.**

On the map locate the main stream, which occupies the valley between Chilton and Stratford, and is crossed by the road which connects these villages. Trace this stream from its source to the point where it flows into the lake.

How many contour lines does the main stream cross in that distance? ....................

How many feet, therefore, does it descend? ........................ In about how many miles? ......................

Make a profile of this valley between its source and its entrance into the lake. The method is the same as for making a cross section, except as follows: Start at the left-hand end of the folded paper in marking the intersections of the contours. As often as the stream bends appreciably, swing your folded edge of paper so that it is continually parallel to the stream's course. Be careful to keep the pivot point on the map and on the folded edge of the paper identical when swinging the paper to a new direction. Plot the results on the cross-section paper, using this time a vertical scale of $\frac{1}{8}'' = 40$ feet.

Where is the stream's profile steepest? ................................................

In what portion of its course is it most gentle? ............................................

What is its average descent per mile near its source? ......................................

In the middle of its course? ..............................................

What information regarding a region can be gained at a glance from a cross section?

..........................................................................................

..........................................................................................

Of what practical use would a profile of two possible roads, that he might follow, be to a farmer intending to haul grain to town?

..........................................................................................

..........................................................................................

..........................................................................................

## XXVI. — PROCESSES OF EROSION AND DEPOSITION

**Materials.** **For General Class Use. — Tank and land model. Spray, nozzle, and hose. (The nozzle should be of the kind used in spraying trees for insects.) Water under pressure.**

**Purpose.** *To study some of the erosional and depositional processes of nature by actual observation of their progress in miniature.*

**The land form.** This land form is supposed to have been newly uplifted from beneath the sea, and no rain has as yet fallen upon it. It is composed of alternate layers of sediment, formed of different kinds of material.

With reference to the compass directions, describe the topography of the land form.

Where is it hilly? ______________________________

______________________________

______________________________

__________ Where has it plains? ______________________________

______________________________ Are there any mountain ranges? __________

________ Are there plateaus? ______________ Any isolated peaks? ______________ Of what material is the surface layer composed? ______________________________

**Characteristics of a young land surface.** Turn the spray upon the land surface. Have it of sufficient volume to develop streams, but avoid having the drops of water too coarse. This spraying is to simulate, as nearly as possible, the rainfall of nature.

What determines the courses of the streams as they flow at first? ______________

______________________________ Why are such streams called *consequent streams?* ______________________________

______________________________ Do any lakes form? ______________ What is the origin of their basins? ______________________________

______________________ Are the divide areas between the stream courses flat or ridgelike? ______________________ What age condition of a land surface does the presence of consequent streams, lakes, and flat-topped divides indicate? ______________________________

______________________________

Examine the stream currents carefully. Are they carrying sediment? ______________

**Transportation and erosion processes.**

If so, where do they get it? ______________________________

______________________________

______________________________

______________ Are they carrying sand particles? ________ How are the sand particles moved along? ______________________________

______________ How much larger stream do you think would be required to move a pebble as big as your fist? ______________ How are clay particles carried along? ______________________________

______________ Can you tell whether the streams are carrying any material in solution? ________

As the currents transport the sand and clay particles, what is the effect on the stream valleys? ______________________________

________ Where are they deepened most? ______________________________

______________ What is meant by *headwater erosion?*

______________________________

______________________________

Do the main streams follow straight courses? ________ What causes them to *meander?*

______________________________

______________________________

______________________________

What is the effect of this meandering on the width of their valleys? ______________

______________ What is meant by *lateral cutting* of a stream? ______________

______________________________

______________________________

______________ By *undercutting?* ______________________________

______________________________

______________________________

What is the shape of the cross section of the stream valleys as they are first cut?

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How is this "gorge-form" cross section changed by the lateral cutting? --------------

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

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Do tributary streams first deepen their valleys near their sources or at their junction with the main valleys? ---------------------------------------------- How do you explain this? ------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

------ What effect has the development of tributary valleys on the flat-topped divides?

----------------------------------------------------------------------------------------------------

**Waterfalls.** Have any waterfalls developed in the stream valleys? -------------- What is their cause? ----------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

Why does a deep pool form beneath them? ----------------------------------------------

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

--------------------- Why do the waterfalls not remain stationary in position? ----------

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------

---------------------- In which direction do their crests move? ---------

**Depositional processes.** Are the sand particles, which the currents are rolling along, carried uninterruptedly to the still water at the mouths of the main streams? ------------------ Where do they lodge?

----------------------------------------------------------------------------------------------------

What do they form? --------------------- Are river bars permanent? ----------------

What is the effect of the formation of a bar on the course of a stream? ________ What large river do you know of which has many sandbars? ________ Why are these dangerous to navigation? ________

Which can carry the most sediment, a slow current or a fast one? ________ Where are currents fastest, on steep or on gentle slopes? ________ If a stream has much sediment in the upper, steep part of its course, what becomes of this sediment when the stream flows over a gentler slope? ________ Examine the streams on the land form to find such a condition. What kind of a topographic feature results? ________ Describe and make a small sketch of an *alluvial fan.* ________

Watch the stream course as it flows over the alluvial fan; why does it shift its position? ________

Does the building up of the alluvial fan make the slope of the stream steeper or more gentle at this point? ________ What is the *grade* of a stream? ________

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------------------------------------------------------------------------------------------

What becomes of the sediment that the stream carries when it enters the still water?

------------------------------------------------ Where are the sand particles deposited?

------------------------------------------------ Where are the clay particles deposited?

------------------------------------------------ Which kind of deposit, sand or clay, covers the larger area of the bottom of the still-water basin? ------------------------

What topographic form do the sand particles build up as they are deposited in the still water? ------------------------ Is the slope of the top of the *delta* steep or gentle?

------------------------ How does the delta compare and contrast with the alluvial fan in outline and slopes? ------------------------------------------------------------

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## XXVII. — INTRODUCTION TO THE STUDY OF LAND FORMS

**Purpose.** *To teach the simple origin of land forms, and the factors which give them complexity.*

NOTE: — This section should be carefully studied before going on with the study of the land in its topographic and cultural relations.

**Types of land forms.** Most land forms are the result of the processes of denudation operating on the rocks of the earth's crust.

The nature and configuration of these forms are dependent primarily and fundamentally on the position and structure of the rocks. There are two fundamental types occupying large areas: —

1. The Plain-plateau Type: The rocks are in horizontal or nearly horizontal beds.
2. The True-mountain Type: The rocks are folded, faulted, and tilted, or are massive crystalline rocks.

Most lesser land forms are resultant upon variations in the conditions and nature of the denudation of these simple, original forms.

**Factors in the development of land forms.** The following factors condition the variation: —

(*a*) The nature of the rock, whether consolidated, or unconsolidated, or partly consolidated.

(*b*) The length of time that the region has been exposed to denudation.

(*c*) The elevation of the region above sea level, and its distance from the sea.

(*d*) The climate, — whether humid or arid.

(*e*) Accidents which have interfered with the normal development of the region. Glaciation and volcanic disturbances, for example, may be considered as such accidents.

With a knowledge of the primary type, whether Plain-plateau or True-mountain, and a consideration of the degree to which the five factors enumerated above have been operative, we can interpret most land forms. Or, by a consideration of the land forms, we can appreciate the factors which determine their present condition.

**Topographic provinces of the United States.** That part of North America which comprises the United States is capable of being divided into a comparatively small number of areas, each of which constitutes a physiographic unit, or province. Moreover, these units bear a most interesting physiographic relation to each other; and, taken collectively, they illustrate practically the whole science of the physical geography of the land. Again, in each of these physiographic provinces the United States Geological Survey has made very fine contour maps, and from these may be chosen one or more which are typical of the province.

The United States, therefore, offers to the American student an excellent opportunity to become acquainted with the science of physical geography of the land in some of its most interesting phases, and to gain a knowledge of the physiographic provinces, and the influence their topography and structure have had on the development of the land, its present industries, and its future possibilities.

The following sections constitute such a study of the regions of the United States. The studies go from the simple to the complex, and, when they are completed, the student should have a comprehensive knowledge of the location of the broader physiographic divisions of the country; and an understanding of the topographic, climatic, and cultural relations of each.

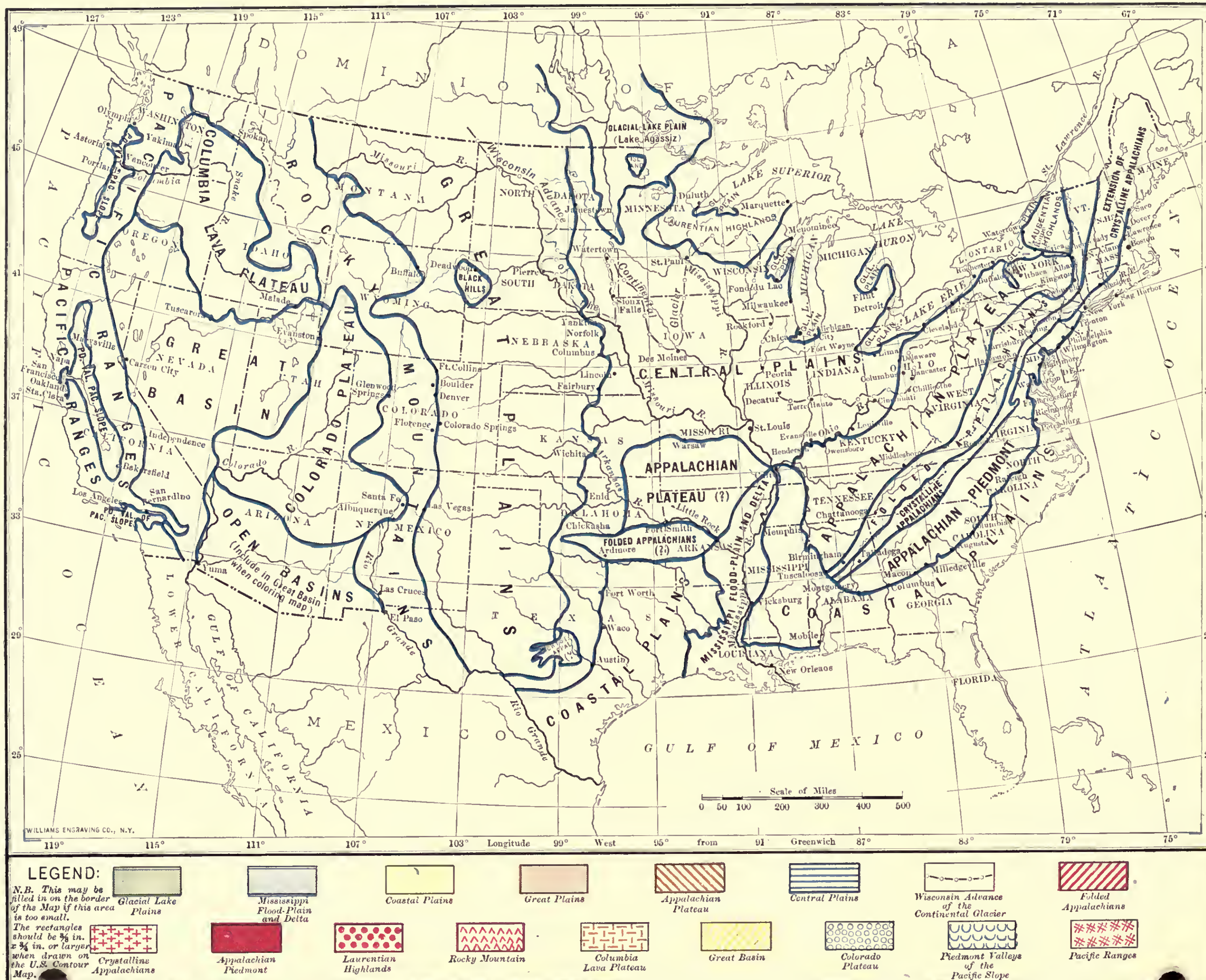


FIG. 21. — DIAGRAM MAP OF THE UNITED STATES SHOWING PHYSIOGRAPHIC PROVINCES. (PRESERVE CAREFULLY.)

## XXVIII. — GLACIAL-LAKE PLAINS

Materials. **For Each Student.** — United States Geological Survey Map of the United States (size 18 x 28 inches) with contours. Fargo sheet, North Dakota-Minnesota. Colored pencils.

Purpose. *To study a very young plain and the influence it exerts on human habitation and industrial development.*

Introductory. When the Continental Glacier of the Glacial Period was receding, after the last (or Wisconsin) advance of the ice (Text-book, Chapter VIII), and had melted back to points near the northern boundary line of the United States, there were times when the ice front remained stationary for a considerable interval. During this long period of recession the ice mass dammed up the north-flowing rivers (for example, the Red River of the North), and their waters spread out and formed huge lakes. (See Text-book, pp. 78 and 149.) Into these lakes much sediment was poured by the streams from the glacier and from the land, and this sediment was deposited on the lake bottom. Finally, after the glacier had melted away completely, the lake waters drained off and the bottoms of the lakes became dry land.

Extent of the Glacial-Lake areas. Figure 21 is a diagram map of the United States on which have been outlined the different physiographic regions studied in this and succeeding sections. The areas which are marked "G. L. P." on the map were formerly bottoms of glacial lakes. Plot the outlines of these Glacial-Lake Plains on your contour map of the United States. Latitude and longitude, the position of state boundary lines, and the location of cities offer the best aids in locating the outline. Extend the Glacial-Lake Agassiz outlines into Canada.

Examine the areas as you have outlined them on your map of the United States. About what proportion of the area of the United States was once covered by glacial lakes?

_______________________________________. What two places along the outlines seem to have been outlets to these lakes? _______________________________________

_______________________________________ What is the highest contour bordering each of these outflow channels? _______________________________________

_______________________________________

_______________________________________

Why was there an island in the Glacial-Lake Agassiz? _______________________________________

_______________________________________ With green pencil, color in lightly (on your contour map of the United States) the regions of the Glacial-Lake Plains. Fill in (with green also) a square for a legend, as indicated on the outline map. Label this square "Glacial-Lake Plains."

Study of a typical area of the Glacial-Lake Plains. Examine the Fargo (N. D.) sheet. What is the most northern degree of latitude shown?

_______________________ The most southern? _______________________ Between what

degrees of longitude is the area included? ____________________________
Locate this area on your United States map and outline it with ink. Letter or write in the name of the sheet beside the rectangle you have drawn. How much larger is the horizontal scale of the topographic map than that of the United States map? ____________________

______________________________________________________________

What is the contour interval of the topographic sheet? ____________________

**A typical cross section.**

Make a cross section between the S of Sabin and the H of Horace, using the same horizontal scale as that of the map, and allowing one vertical division of the cross-section paper for every 20 feet of elevation. On each cross section you make always mark the name of the sheet, the points between which it is taken, the horizontal scale, and the vertical scale adopted.

**Interpretation of the topography.**

What, in general, is the nature of this land surface, as shown by the distance apart of the contour lines and the cross section you have made? ____________________

____________________ What is the shape of the stream valleys as shown by your cross section? ____________________

____________________ How deep are they? ____________________

____________________ How wide? __________

____________________ Are this shape and size characteristic of an old or young valley? ____________________

____________________ What is the nature of the divides between the stream valleys? ____________________ Why would rain water run off very slowly from this region? ____________________ In which direction do the main streams flow? ____________________ What is the difference in elevation between the highest and lowest points on the map?

____________________ Where is the highest point? ____________________

The lowest point? ____________________

**Human occupation.**

What are the directions of the wagon roads in this region? ____________________

____________________ What is their pattern, or arrangement? ____________________ Why is it possible for the railroads to have such straight courses? ____________________

What kind of deposits are laid down in still water, fine or coarse grained? __________

__________ What two reasons can you give why this should be a fine agricultural region?

Why are many farmers now crossing into Canada to the region north of this part of the United States? ____________________

____________________

____________________

__________

Count the number of houses in ten adjoining squares. ____________ Allowing five people to each house, what is the average population per square mile in this section?

____________________ What is the position of the houses with respect to the roads? ____________________

Write a short paragraph, below, explaining why the deposit of sediment over a lake bottom would, on the disappearance of the lake waters, give a region of this nature, and tell why such a region encourages agricultural industry.

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## XXIX.—THE MISSISSIPPI FLOOD PLAIN AND DELTA

Materials.

**For Each Student.**—Geological survey map of the United States, used in preceding exercise. Donaldsonville (La.) sheet. Colored pencils.

**For General Class Use.**—Chart No. 14. Mississippi River Commission. The Fargo (N. D.) sheet.

Purpose.

*To study a very young plain in process of formation by river deposit; and the conditions affecting human occupation of this plain.*

Introductory.

The Mississippi River, in its lower course, carries enormous amounts of sediment in its waters. In places it deposits some of this sediment, in others it secures more. At its mouth it deposits all its load. The flood plain and delta of the Mississippi are built up of such sediment deposits, and the river is continually modifying the flood plain, and extending the delta. (See Text-book, pp. 61–66, 325–328.)

Extent of the Mississippi Flood-plain and Delta area.

On your contour map of the United States plot the outline of the area marked M. Fl. P. and D. on Fig. 21. About what proportion of the area of the United States does the Mississippi Flood-plain and Delta region constitute? ________________ What is the approximate length of this area in miles? ______________________________________________ What is its average width? ______________________________________________ What is the pattern of the smaller streams on the flood plain and delta? ________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

Are they many or few as compared to adjoining regions? ________________________________

At the mouth of the Ohio River the altitude of the Mississippi River is 294 feet above the sea. The distance from the mouth of the Ohio to the mouth (head of passes) of the Mississippi is 1060 miles. What is the average descent (in feet per mile) of the Mississippi between the mouth of the Ohio and its mouth at the Gulf of Mexico? ________________________________________

With blue pencil, color in lightly on your contour map of the United States the area of the Mississippi Flood-plain and Delta region. Fill in (with blue pencil also) a legend square, as indicated on the outline map (Fig. 21).

Study of Mississippi River Chart No. 14.

What is the scale of this chart? ______________________________________________________

What is the nature of the river's course as shown on this chart? ____________________________

How long are the river bends? ..............................................................

.................................... On which side of the bends is the river depositing material?

..............................................................................................

Do these bars have a constant shape and position? (See red lines and legend explaining them.)

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Which is the shortest course, around the bends or across the necks of land between them?

.............................. Why does the river often change its course, especially during a flood when part of the waters can flow over such necks of land? ..............................

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What does the abandoned portion of the river become after a new course is established?

.................................................. Give an example of such a change as shown on the chart. ..............................................................................

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Why must the river be often resurveyed? ..............................................................

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**Study of a typical Mississippi Flood-plain and Delta area.**

The Donaldsonville (La.) sheet shows, in detail, typical conditions of this region. Locate and plot the area of this sheet on your United States map, outlining it with ink. Letter or write in the name of the sheet.

What is the contour interval on this sheet? ............................ Why was not a larger interval used? ..............................................................................

Make a cross section between Bayou Verrette and the nearest point of the swamp on the opposite (east) side of the river. Allow one vertical division of your cross-section paper for every ten feet of elevation. On the cross section, indicate the line along which it is made, and also the horizontal and vertical scale.

As shown by your cross section, where are the highest points in the flood plain? ________

How do you explain this condition? (Natural levee, Text-book, p. 62.) ________

In what direction do the small streams near the Mississippi flow? ________ Why can not the large swamps be drained? ________

Why does the Mississippi so readily change its course in flood times? ________

What is the stage of the development of drainage conditions here, as compared to those in the Glacial-Lake Plains regions? ________

Is this, then, a younger or older region in development than the Glacial-Lake Plains areas? ________

**Human occupation.**

Describe the position and course of the main roads of this area. ________

How do you account for their arrangement? ________

What is the direction of the secondary roads? ______________________________

____________________________________________________________________________

______________________________________________________Where do they end?

____________________________________________________________________________

What is the average width of the habitable area of the inner flood plain, as shown on this sheet? ______________________________________________________________

Where are the majority of the houses located? ______________________________

______________________________________ About how many houses are there along a mile of river bank? ______________________________ What population per square mile does this indicate? ______________________________

Does such a population indicate that the flood plain is rich or poor agricultural land?

____________________________________________________________________________

Why is a region with such large areas of swamp land not healthful? ______________

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Write a short paragraph summarizing the conditions along the Mississippi River in its lower course.

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## XXX. — THE COASTAL PLAIN

**Materials.** **For Each Student. — The contour map of the United States. Winterville (N.C.) sheet. Colored pencils.**

**For General Class Use. — Fargo (N.D.) sheet. Donaldsonville (La.) sheet.**

**Purpose.** *To study a young plain recently uplifted above sea level, and to compare the conditions on it with that of other young plains previously studied.*

**Introductory.** The region of the United States bordering the eastern and southern coast, from New York City southward to Mexico, except where broken by the Mississippi flood plain and delta, is a Coastal Plain. That is, it consists of layers of sediment deposited on the ocean floor and then, by a change in the level of the land, lifted out of the water. (Text-book, pp. 72–75, 305–306.)

**Extent of the Coastal Plain.** On your contour map of the United States plot the outlines of the areas marked Coastal Plain in Fig. 21. Estimate what proportion of the area of the United States the Coastal Plain region constitutes. ______________________________ Of what states does it form the larger part? ______________________________

______________________________

______________________________

**Broad relations.** Southern Florida is different from the rest of the Coastal Plain in that it is underlain by limestone. How may this fact account for the many lakes mapped on its surface? (Text-book, p. 60.) ______________________________

______________________________

______________________________

What other region having many lakes have you studied? ______________________________

____________What does the presence of lakes and swamps indicate as to drainage conditions?

______________________________

Along the inland margin of the Coastal Plain, on the Atlantic coast, the soft, loose sediments of the plain rest against more resistant crystalline rocks, such as granites, schists, and gneisses. The rivers of this region flow down across these hard rocks, and then on to the soft strata of the Coastal Plain. In which of these classes of rock can streams erode the more rapidly? ______________________________ Why would the "Fall Line" (as this contact line of the hard and soft rocks is called) be an especially favorable site for the growth of cities? ------------------------------------------------------------------------

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Make a list of the important cities located along the "Fall Line," and the river on which they are situated. ------------------------------------------------------------------------

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On your contour map of the United States color in lightly, with yellow pencil, the area of the Coastal Plain regions. Fill in a legend square (with yellow pencil also) as indicated on the diagram map (Fig. 21) and mark it Coastal Plains.

**Study of a typical section of the Coastal Plain.**

The Winterville (N.C.) sheet presents, in detail, typical conditions of the Coastal Plain area. Locate and plot the area of this sheet on your United States map, outlining it with ink. Letter or write in the name of the sheet.

What would be the surface topography of a coastal plain just after it was lifted above the sea? ------------------------------------------------------------------------

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What has happened to this part of the plain since its uplift above the sea? ----------------

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------------------------------------------------------------------------ What areas have conditions resembling the original surface? ----------------------------------------

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---------------------------------------- What do such divides between streams indicate as to the age of the region where they occur? ----------------------------------------

---------------------------------------- What is the contour interval of this sheet?

---------------------- What is the present average elevation of the region above the sea level? ----------------------------------------

**Profile of a Coastal Plain stream.**

Make a longitudinal profile (in the manner directed in exercise No. XXV) of the valley of Hardee Creek from its mouth at the Tar River to its source. Where is the slope of the valley greatest, near its mouth or its source? ____________________
What does this indicate as to the kind and position of the erosion which the stream is accomplishing? ____________________

____________________

How deep is this valley at a point about two miles from its mouth? ____________________

____________________ How wide? ____________________

What form of cross section has it? ____________________

____________________ How will this cross section be modified as time passes?

____________________

____________________

**Comparison with drainage conditions on other young plains.**

What similarities in valley form have the streams on this sheet with those of the Fargo sheet? ____________________

____________________

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What differences in the conditions in the valley bottoms? ____________________

____________________

____________________ How may the greater elevation of the Fargo region help to account for the less swampy conditions on it? ____________________

____________________

____________________ What is the elevation above sea level of the major portion of the area of Donaldsonville, Louisiana sheet?

____________________ How does the amount of swamp land there compare with that on the Winterville sheet? ____________________

What similarity in the nature of the divides exists between the Fargo region and the Winterville Coastal Plain region? ____________________

____________________

**Human occupation.**

What is the pattern of the roads on the Winterville sheet as compared to the Fargo sheet? ____________________

Is this difference wholly or partly due to a difference in topography? ____________________

What areas do the roads on the Winterville sheet especially avoid? ____________________

____________________ On comparing the courses of the railroad lines and the wagon roads on the Winterville sheet, what reasons can you suggest for the greater irregularity of the wagon roads? ____________________

____________________

How does the density of population in this area compare with that indicated on the Fargo sheet and the Donaldsonville sheet? ____________________

____________________ How do you account for the difference? ____________________

____________________ What do such place names as "Green's Mill Run," "Harris Mill Run," "Plank Road," "Gum Swamp," and the comparative sparseness of the population suggest as to the industry of the region?

____________________

Write a short paragraph summarizing the topographic conditions which characterize the Coastal Plains province and the nature of its settlement.

____________________

## XXXI. — THE GREAT PLAINS

**Materials.** **For Each Student. — Contour map of the United States. Mt. Carrizo (Col.) sheet, Syracuse (Kan.) sheet, Kearney (Neb.) sheet. Colored pencils.**

**Purpose.** *To study the development of topography, and its influence on settlement, in a region of high plains which has an arid climate.*

**Introductory.** The plains studied in the preceding exercises were of comparatively low elevation, and in a humid climate. The Great Plains region has, in general, a much greater elevation and a much more arid climate. The rocks, however, are similar in origin and position to those of the Coastal Plains, — that is, they are sediments laid down in former seas, and still lie in nearly horizontal position; but, being more firmly consolidated, they are more resistant to denudation than the rocks of the Coastal Plains. Therefore, in the Great Plains we study the topography resulting when a region of plains has been subjected to a marked uplift, and exposed to the agents of weathering and erosion in an arid climate; also, the effects of such a climate on the human occupation of the region. (Text-book, pp. 77, 326–327.)

**Location and extent of the Great Plains.** On your contour map of the United States outline the area of the Great Plains, as shown on the diagram map (Fig. 21). What meridian marks the general eastern limit of the Great Plains? ______________________________ What determines their western boundary? ______________________________ What is their approximate elevation above the sea, as shown by the contour lines on the United States contour map?

______________________________ How does this compare with the elevation of the Coastal Plains? ______________________________

______________ Parts of what states are included in the area of the Great Plains?

______________________________

______________________________

How do the Great Plains compare in extent with the regions previously studied? __________

______________________________ What is the general industrial and agricultural development of the Great Plains, as indicated by the number of important cities on them, and as compared in this respect with the regions previously studied? ______________________________

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Color in lightly (with brown pencil) the area of the Great Plains as you have outlined it on your United States contour map. Also color in a legend square with brown, and mark it Great Plains.

**Study of typical areas of the Great Plains.**

Locate the position of the Mt. Carrizo (Col.) sheet on the United States map and outline with ink the area it includes. Also letter or write in the name of the sheet on the map.

Near which border of the Great Plains is this area located? ____________________________

______________________ What is the elevation of this border as compared to the Mississippi Valley in the same latitude? ________________________________________________

________________________________ What average slope (approximately) would this give to streams flowing toward the east? ________________________________________________

____________________________________ How would such a slope affect their power of erosion?

______________________________________________

______________________________________________

**Topography of the western border.**

Make a cross section along a line extending from a point 2 inches southeast of the last "A" in Animas, through the "z" in Mt. Carrizo, and continuing for $3\frac{1}{2}$ inches in the same direction. Use the same horizontal scale as that of the map, and let one division of the cross-section paper equal one hundred feet in the vertical scale.

What is the nature of the stream valleys as shown by this cross section? _______________

______________________________________________

______________________________________________

What does the fact that the streams are marked by dotted blue lines indicate? (See Fig. 20.)

______________________________________________

If after a long dry period, a heavy rain occurred, why would the water drain off quickly?

______________________________________________

____________________________________________ What would be the effect of this rapid run-off on the stream valleys? ________________________________________________

______________________________________________

Why would erosion be more effective than weathering in this region? ______________________

______________________________________________

-------------------------------------------------------------- What is the topography of the divide areas between streams? ----------------------------------------

Describe the shape, slopes, and top of Mount Carrizo as shown by the map and your cross section. ----------------------------------------

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Is it a true mountain? -------------- What kind of a land form is it? ----------------------------------------

------------------------ Why do *mesas* develop extensively in arid and not in humid regions, even though both have horizontal strata? ----------------------------------------

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---------------------------------------- What is the difference between a *butte* and a mesa as illustrated in Potato Butte and Fowler Mesa? ----------------------------------------

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**Human occupation along western border.**

Some habitations are undoubtedly located in this area, but they are not shown on this map. What, however, does the small number of roads indicate as to the extent of settlement?

---------------------------------------- What two conditions would prohibit dense settlement in this region? ----------------------------------------

------------------------

**Topography of the Central Great Plains.**

Locate the position of the Syracuse (Kan.) sheet on the United States map and outline with ink the area it includes. Also letter or write in the name of the sheet on the map.

What reasons can you suggest why the southern part of this area is much less dissected than the Mt. Carrizo region? ----------------------------------------

----------------------------------------

---------------------------------- Make a cross section of the country on a line between Gognac in the southeast corner, and Edwin about twelve miles to the northwest. What is the general topography of the country as shown by this cross section? ----------------------------------------

---------------------------------------------------------- This is typical of wide expanses of the Great Plains. Why is there much greater dissection in the northern part of the sheet?

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What effect has this greater dissection on the course of the roads? --------------------------

------------------------------------------------------------------ What is the significance of the small areas inclosed by saw-edged brown lines (Fig. 20)? ---------------------------

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-----------------------------------------------------------------

**Human occupation in Central Great Plains.**

How does this region compare in density of population (as indicated by roads and towns) with that of the Mt. Carrizo region? ---------------------------------------------------

------------------------------------ What does the scattered location of the houses suggest as to the agricultural possibilities of this region? ----------------------------------------------

----------------------------------------------- What curious relation do you note regarding the number of houses and streets in the towns of Johnson and Kendall? -------------------

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**Topography of the eastern border of the Great Plains.**

Locate the position of the Kearney (Neb.) sheet on the United States map, and outline with ink the area it includes. Also letter or write in the name of the sheet on the map.

What is the character of the eastern portion of Platte River, as shown by this map?

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What causes this *braided* channel condition? ------------------------------------------------

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---------------------------------------------- What is the source of the sediment supply?

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Why is it deposited in this eastern portion of the river? ------------------------------------

-------------------------------------------------------- What is the nature of the topography to the north of the Platte River? ______________________________

______________________ To the south? ______________________

______________________ These numerous depressions and small, low summits are the topography of a sandhill area. What is the source of the sand supply?

______________________________________________

What must be the prevailing wind direction? ______________________

**Human occupation of eastern border.**

What difference is shown on this sheet in the extent of continuously flowing streams as compared to those of the Central and Western Great Plains areas? ______________________

______________________________________________

______________________________________ What does this indicate as to the difference in climate from west to east? ______________________

______________________ What is the effect of this difference in climate on the density of settlement? ______________________

______________________ What difference in the nature of agricultural industry, in the western and eastern parts of the Great Plains, does this difference in density of population indicate? ______________________

______________________________________________

______________________________________________

Write a short paragraph summarizing the origin and nature of the topography, and the human occupation of the Great Plains region.

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## XXXII. — THE APPALACHIAN PLATEAU

**Materials.**

**For Each Student. — The contour map of the United States. The Centerpoint (W.Va.) sheet. Colored pencils.**

**For General Class Use. — The Mt. Carrizo (Col.) sheet.**

**Purpose.**

*To study the topography and settlement in a region of elevated horizontal strata (a high plain or plateau) where the climate is humid, and which has been denuded for a long period.*

**Introductory.**

The Appalachian Plateau bears the same relation to the Appalachian Mountains that the Great Plains do to the Rocky Mountains, — that is, the Appalachian Plateau is a region of elevated, horizontal strata, located on the inland side of the Appalachian Mountains. The Appalachian Plateau contrasts with the Great Plains in that it lies in a humid climate, has been denuded longer, and is made up of harder rocks than the Great Plains. (Text-book, p. 84.)

**Location and extent of the region.**

On your contour map of the United States outline the area of the Appalachian Plateau, as shown on the diagram map (Fig. 21). What is the size of this region as compared to that of the Great Plains? ______________________________________________. What parts of what states are included in it? ______________________________________________

______________________________________________

______________________________________________

______________________________________________

__________________________What is the approximate elevation of the Appalachian Plateau?

______________________________________________How does this compare with the Great Plains region? ______________________________________________

Color in, with ruled brown lines (as indicated by the pattern of the legend square on the diagram map, Fig. 21), the area of the Appalachian Plateau as you have outlined it on your United States contour map. Add the proper legend square, and mark it, Appal. Plat.

**Study of a typical section of the Appalachian Plateau.**

Locate the position of the Centerpoint (W. Va.) sheet on the United States map and outline with ink the area it includes. Also letter or write in the name of the sheet.

Set down the height of ten different hill summits from different parts of the sheet.

______________________________________________

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______________________________________________

How do they compare in height? ______________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________ If the valleys were all filled in, what would be the appearance of this region? ______________________________________________

______________________ What was the original topography of this region as suggested by the uniform height of the hills? ______________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________ What has taken place since? ____________________

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______________________________________________________________________________

Make a cross section along a line running northwestward between the towns of Cascara and Roberts. Use the same horizontal scale as that of the map, and let one division of the cross-section paper equal sixty feet in the vertical scale. (This will give a cross section comparable (nearly) to the one made of the Great Plains.) In making this cross section it will not be necessary to mark all the intersections of the contour lines; those showing the elevation of the hilltops and the valley bottoms will be sufficient to give good results.

What is the form of the valley cross sections in this region as compared with those of the Great Plains? ______________________________________________

______________________________________________________________________________

How do the divides between streams compare in form in the two regions? ______________

______________________________________________________________________________

______________________________________________________________________________

What is the age stage of a region which has V-shaped valleys and ridge divides? ______________________________________ Is this a more arid or more humid region than the Great Plains? ______________________________________ Why would greater humidity accelerate weathering and the formation of ridge divides? ____________________

______________________________________________________________________________

**Human occupation.**

What determines the course of the roads in this region? ______________________________

______________________________ Why is this the case?

______________________________

Where are the houses and towns located? ______________________________

______________________________ Why are there so few houses on the ridges and the valley slopes? ______________________________

______________________________ Would this region be easier or more difficult to cross than the Great Plains region? ______________________________ If transportation is so much more difficult, why is there a so much greater population than in that part of the Great Plains that lies near the mountains? ______________________________

______________________________

______________________________

______________________________ Why do extensive forests still remain in this region?

______________________________

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Where the forest is cleared off is the land better suited to sheep raising or the raising of crops?

______________________________ What would be the effect of the discovery of coal or iron on the settlement of such a region as this? ______________________________

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Write a short paragraph describing a plateau region in a humid climate having mature drainage conditions; and tell why such a region is difficult of settlement and development.

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## XXXIII. — THE CENTRAL PLAINS REGION

**Materials.** **For Each Student. — The contour map of the United States. Caldwell (Kan.) sheet, Fargo (N.D.) sheet, Centerpoint (W.Va.) sheet. Colored pencils.**

**Purpose.** *To study a plains region in which the erosion cycle has advanced to the old age stage.*

**Introductory.** The Fargo and Centerpoint sheets are typical of plains regions in which the topography and drainage conditions are respectively young and mature. The Caldwell sheet of the Central Plains province typifies a plains region where the erosion cycle has continued until the country has acquired the characteristics of a plains region in old age. Thus the three regions, of which these sheets are typical, illustrate the stages in the development of plains topography from youth to old age. (Text-book, pp. 76–78 and 310–314.)

**Location and extent of the Central Plains province.** On your contour map of the United States outline the area of the Central Plains province as shown on the diagram map (Fig. 21). What proportion of the area of the United States does this region constitute? ______________________________ What is its approximate elevation above sea level? ______________________________

What large cities are located in the Central Plains province? ______________________________

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What reasons can you give to account for the great importance of this region in the development of the country? ______________________________

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What is the general slope of the region? ______________________________

What are its secondary slopes? ______________________________

______________________________________________________________

Color in, with ruled blue lines (as indicated by the pattern of the legend square on the diagram map, Fig. 21), the area of the Central Plains region as you have outlined it on your

United States contour map. Also add the proper legend square and mark it Central Plains region.

**Study of a typical section of the Central Plains in the southern part.**

Locate the position of the Caldwell (Kan.) sheet on the United States map, and with ink outline the area it includes. Letter in the name of the sheet.

In what part of the Central Plains is this area located? ____________________ ____________ Judging by your previous study of regions to the east and west of the Central Plains, would this area have more or less rainfall than parts of the Central Plains to the east? ____________________ What indications of light rainfall do you find on the Caldwell sheet? ____________________ ____________________ What indications are there, however, that the rainfall is sufficient for successful agriculture? ____________________

How many square miles of land are shown on the Caldwell sheet? ____________ ____________ What is the highest point on the sheet? ____________ The lowest? ____________ What is the average direction of slope? ____________ ____________________ What then is the general topography of the area? ____________________

____________________________________________

____________________________________________

____________________________________________

Make a cross section (along a north-south line) between the station Doster, on the St. Louis, Kansas, and Southwestern Railroad, and the Sante Fé Railroad. Use the same horizontal scale as that of the map, and let one section of the cross-section paper equal forty feet vertical scale.

Make a profile of Fall Creek from its intersection with the St. Louis, Kansas, and Southwestern Railway to its source, using the same vertical scale as in the cross section.

What are the shapes of the valley cross sections? ____________________ ____________________ How do they differ from those of the Fargo sheet? ____________________

____________________________________________

____________________________________________

____________ How are they different from those of the Centerpoint sheet?

How do these three regions compare as to the amount of elevation above sea level?

By what processes of denudation might the valleys of the Centerpoint sheet be modified so that they would resemble those of the Caldwell sheet?

Would a long time or a short time, physiographically speaking, be required to bring about such a modification?

Why are there no swamps in the stream bottoms of the Caldwell sheet, although the stream courses are meandering?

What is meant by saying that a stream has reached *grade?*

What is the character and outline of the divides between the streams?

How do these differ from those of the Fargo sheet, on the one hand, and the Centerpoint sheet on the other?

Diagram the pattern of

the drainage system on the Caldwell sheet, showing how a large stream is fed by tributaries, and these in turn by smaller tributaries, and so on.

Why is such a drainage system called *dendritic?* ______________________________________

______________________________________________________________ Is the angle between a tributary and a main stream acute or obtuse on the upstream side? ________________________

What are the conditions on the Fargo sheet in this respect? ______________________________

_________________________________________________________

**Human occupation.** What is the pattern of the wagon roads on the Caldwell sheet? ___________________

___________________________ Why is such a pattern possible here? _________________________

______________________________________________________________________________________

______________________________________________________________________________________

Do the railways attempt to follow the lines of the divides or of the stream valleys?

____________________________________________ Are the bends in the course of the Wichita and Western division of the Missouri-Pacific Railroad necessitated by the topography, or by a desire to touch at every small town? ________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

____________________________________________ Why would such a course be impossible on the Appalachian Plateau?

What determines the location of towns in the region of the Caldwell sheet?

Why have some towns grown to a larger size than others? No houses are plotted on this sheet. Would you infer from this that this is a sparsely settled region? What do the number of small towns, the number and pattern of the roads, and the number of railroads indicate in this connection?

Write a short paragraph comparing and contrasting the topography, drainage, and human occupation in plains regions in youth, maturity, and old age, as studied in this and the preceding exercises.

## XXXIV. — THE AREA OF CONTINENTAL GLACIATION IN THE UNITED STATES

**Materials.** **For Each Student. — The contour map of the United States. The Whitewater (Wis.) sheet, the Caldwell (Kan.) sheet.**

**Purpose.** *To gain an appreciation of the area of the United States that was affected by the continental glacier during the glacial period; and to study a portion of the glaciated area where the effects of the ice advance and retreat were very pronounced.*

**Introductory.** In the preceding exercises, plains regions, whose structure was in every case horizontally bedded sediments, have been studied to bring out the variation in their topography and development as dependent on their age, their elevation, and their location in a humid or arid climate. The erosion cycle in each of the regions thus far studied may be considered as having continued uninterruptedly. However, it may happen that what can be termed an unexpected factor is introduced at some stage in this cycle; and, in that case, the drainage of the region is said to have suffered an *accident.* Such an accident was the occurrence of the period of continental glaciation in northern United States.

In regions where the topography was irregular and well defined, as, for example, in mountainous or dissected plateau regions, the effect of the glaciation was not of a dominating character on the appearance of the region as we know it to-day. On regions like the Central Plains area, on the other hand, which had advanced to the gentle relief of an old-age stage, the effect of the glacial advance was very marked and striking. (Text-book, pp. 148–149 and 154–156.)

**Location and extent of the area of continental glaciation in the United States.** The line of dashes and circles on the diagram map (Fig. 21) marks the outline of the greatest extension of the ice sheet of the Wisconsin advance of the continental glacier. Plot this outline in ink on your contour map of the United States, using the same symbols. Fill in also a legend square, as indicated on the diagram map (Fig. 21).

Where did the continental glacier advance farthest south? ______________________________

____________________________________________________________ What effect did the presence of the Appalachian Plateau have on the advance of the ice in the eastern part of the United States? ____________________________________________________________

Why did the region around the western end of Lake Superior have a similar effect?

____________________________________________________________

What comparison can you make regarding the number of lakes within and outside the area of glaciation? ____________________________________________________________

____________________________________________________________

____________________________________________________________

______________ What suggestion as to the origin of the basin of Lake Michigan do you find on comparing the direction of its extension and that of the ice lobe that covered this region?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

To which of the other Great Lakes might this explanation be also applied? ____________________

______________________________________________________________ Is the region of densest population of the United States within or outside of the area of continental glaciation?

______________________________________________________________________

**Study of a section of the Central Plains glaciated area.** The Whitewater (Wis.) sheet illustrates conditions which are more or less common in that part of the Central Plains within the area of continental glaciation. Locate the position of the sheet on your United States map, and outline its area with ink. Letter or write in the name of the sheet.

Is there any system to the topographic features shown on this sheet? ______________

What is the condition of the drainage of the area? ______________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Have the streams any general direction of flow? ______________ How can these drainage conditions be accounted for by assuming the former presence of a great ice sheet? _________

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______________________________________________________________________

What would be the effect, on a region in an old-age stage of development, of dumping great masses of débris without regard to order or system in arrangement, or amount deposited, in any one place? ____________________________________________________________

______________________________________________________________________

Why is the drainage system in a glaciated area said to have suffered an accident?

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What is the origin of the many lakes? ---

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The band of low hills and depressions which extends across the southeastern portion of the sheet is a terminal moraine. Make a cross section of it on a line between the northern end of Lauderdale Lake and the word "Prairie" of the Prairie du Chien division of the Chicago, Milwaukee, and St. Paul Railroad. Let one section of the cross-section paper equal twenty feet in the vertical scale.

Describe the topography of a moraine ridge as shown by this cross section. ---

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What is the cause of the small lakes and ponds on the moraine ridge? ---

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**Human occupation.**

What pattern of roads was attempted in this area? ---

What features interfered with carrying it out? ---

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What reasons seem to justify the building of wagon roads across the large swamps? ---

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How are the courses of the roads affected in crossing the moraine ridge? ---

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How could large areas of this region be reclaimed for agricultural purposes? ---

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## XXXV. — A REGION OF DRUMLINS

**Materials.** **For Each Student. — The contour map of the United States. The Weedsport (N.Y.) sheet.**

**Purpose.** *To study a striking topographic phenomenon due to continental glaciation.*

**Introductory.** Over several large areas within the region of continental glaciation in the United States (*e.g.* in Massachusetts, New York, and Wisconsin), the ice sheet produced remarkable clusters of low hills, to which the name *drumlin* has been given. Their height, shape, and alignment afford evidence as to the direction and nature of the ice movement. So far as known the drumlins are, in the main, composed of unstratified clay and bowlders, called *till.* (Text-book, pp. 152–153.)

**Study of a drumlin area.** The Weedsport (N.Y.) sheet shows a typical drumlin area. Locate this area on your United States map, and outline it with ink. Letter or write in the name of the sheet beside the rectangle.

What is the most striking topographic feature of this sheet? ____________________

________________________________________

________________________________________

What is the pattern, or arrangement, of the many hills? ____________________

________________________________________

________________________________________

What is their general compass direction? ____________________

What would you infer from the arrangement and development of the drumlin hills as to the direction of movement of the ice mass which made them? ____________________

How do the drumlins influence courses of streams? ____________________

________________________________________

________________________________________

________________________________________

**Study of individual drumlins.** Are the lakes and swamps in this area due to the presence of the drumlins? ____________________

Draw, freehand, small longitudinal profiles and width cross sections of a number of drumlins in the space provided on the next page.

On which end have they the steepest slopes? ______________________ What variation is there in the slope and shape of the other end? ______________________________________________

______________________________________________________________________________

______________________________________________________________________________

Does the slope of the two sides also vary in any one typical drumlin? ______________________
What is the height (from base to top) of six different drumlins on different parts of the sheet? ______________________________________________________________________

______________________________________________________________________________

What is their average height? ______________________________ What is their average width? ______________________________ How do they vary in length? ______________________________

______________________________________________________________________________

______________________________________________________________________________

**Human occupation.** Why would tillage be difficult on all parts of drumlins? ______________________________

______________________________________________________________________________

What conditions interfere with agricultural pursuits in many of the depressions between the drumlins? ______________________________________________ How have the drumlins affected the courses of the wagon roads and railroads? ______________________________________________

______________________________________________________________________________

______________________________________________________________________________

## XXXVI. — THE NIAGARA REGION

**Materials.** **For Each Student. — The Niagara Falls and vicinity sheet, published 1901.**

**Purpose.** *To study the course and physiographic relations of the Niagara River.*

**Introductory.** The Niagara River is a stream which owes its existence to the effects of the continental glacier. Before the glacial period the drainage of this region was of an altogether different nature, and there was then no important stream having the course of the present Niagara. Therefore the Niagara River may be studied as a young river whose course is due to the accident of glaciation. (Text-book, pp. 330–334.)

**General features of the Niagara River.** What is the source of the Niagara River? ______________ Where is its outlet? ______________ What is its approximate length? ______________ What is its average width (considering both arms) above the Falls? ______________ Below the Falls? ______________ In which part must it be deeper and more rapid? ______________

**Upper Niagara.** What is the topography of the region over which the upper Niagara flows? ______________ Make a cross section on a line between Inland and Pullman (near Buffalo). Let one section of the cross-section paper equal forty feet in the vertical scale. What is the nature of the banks of the upper Niagara River? ______________ How does this cross section compare with that of the Mississippi? Why is the upper Niagara River free from sediment? ______________ Why is it free from floods? ______________ What is the elevation (approximate) of the upper Niagara Plain (Erie Plain)? ______________

**Lower Niagara River and the Niagara Escarpment.** What is the elevation of the Lower Niagara River Plain (Ontario Plain) near Lewiston? ______________ By what topographic feature are the two plains separated? ______________ How high is the Niagara Escarpment? ______________ How steep is its slope near the Niagara River? ______________

In what direction does the escarpment extend?

Make a cross section across the lower Niagara River on a line between Four Mile Creek and the Michigan Central Railroad. Use the same vertical scale as in the cross section of the Upper River. How do the two cross sections compare?

**The gorge section of the Niagara River.**

How long is the gorge section of the Niagara River? What marks the limit of its upstream extension? What marks the limit of its downstream extension? At which end is it growing longer? What was the first position of the Falls? (Text-book, p. 332.) If the cataract receded at the same rate as at present (about 5 feet per year), during all the period of its existence, how long did it take to cut the gorge? Why are *hachures,* instead of contour lines, used on the gorge section of the river?

Make a cross section of the gorge (extending two miles on either side) on a line parallel to the Niagara Escarpment and one mile south of it. Use the same vertical scale as in the preceding cross section, and assume that the gorge is as deep as the escarpment is high. Describe this cross section and compare it with those of the upper and lower Niagara River.

Why is the river so much narrower in the gorge than on either plain?

What evidence is there that the northwest bank of the Whirlpool is made of softer material than other parts of the gorge wall?

**The Falls.** How high are Niagara Falls? What is the outline of the crest of the Canadian Falls? The American Falls? Why has the Niagara River a greater sediment load below than above the Falls?

In what way does the presence of Niagara Falls and Gorge affect navigation?

How does this account for the location of Buffalo?

Why is there not a city of equal importance at the southern end of Lake Huron?

Where does the Erie Canal begin?

What reasons can you give for the location of Tonawanda?

Why is the shipping of Lake Ontario of less importance than that of the upper Great Lakes?

Why are there many manufacturing establishments at Niagara Falls City?

How will the further development of Niagara power affect the surrounding region?

What other reason can you give for the location of a city at Niagara Falls?

## XXXVII. — PLAINS CITIES AND THEIR ENVIRONS

**Materials.** **For Each Student. — The Cleveland and Vicinity sheet, the St. Louis sheet, the Denver quadrangle.**

**Purpose.** *To gain an appreciation of the factors which influence the location and growth of cities, and the effect of the cities on, and their response to, their physiographic environment.*

**Introductory.** Cities on the seacoast, and in mountains, which grow to a large size, owe their growth, in the main, to some especially favorable factor of environment which dominates all other disadvantages the site may have. In the case of plains cities, however, there is a wider variety of possible locations, and the large city becomes established because of a variety of interacting lesser influences combining to give one site an advantage over its rivals. (Text-book, pp. 166, 312, 315, 375–377.)

**Broad relations.** Examine the topographic sheets for the cities of Cleveland, St. Louis, and Denver. What is the one dominating factor which made possible the growth of Cleveland and St. Louis?

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What topographic feature prevented the growth of a large city farther to the west than is Denver? ------------------------------------------------------------

Why are transportation conditions of such supreme importance in fixing the sites of great cities? ------------------------------------------------------------

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What are the chief industries of cities? ----------------------------------------

---------------------------------------- Of what advantage is it to a city to have a rich agricultural country immediately tributary to it? ----------------------------------------

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-------------------------- How would this fact affect the growth of Denver as compared to Cleveland and St. Louis? ----------------------------------------------------

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______________________________ Is Denver of more importance as a commercial center, or as a manufacturing center? ____________________________________________________________

________________________________________________________________________________

Note that the growth of Denver has been a radial one,—that is, from the center outwards. What is the significance of this in regard to the favorableness for habitation of the surrounding area? ________________________________________________________________

________________________________________________________________________________

Cleveland has grown outwards from the diameter of a circle. What reasons can you assign for this fact? ____________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

Why, on the other hand, has the growth of St. Louis been focused on the circumference of a circle? ____________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

What are the two great interior waterways of the United States? ____________________

________________________________________________________________________________

__________________________________________________________________ On which of these is St. Louis located? __________________________________________ Cleveland? __________

________________________________ What advantage has Cleveland with regard to the location of the eastern coalfields which enables it to compete with Chicago? ______________________

________________________________________________________________________________

________________________________________________________________________________

______________________________________________________________ Why can St. Louis successfully compete with Chicago in marketing her manufactures in the Southern States?

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

What is the elevation of the land on all sides of Denver as compared to the site of the city itself? ______________________ What advantage does such a site offer as compared to the adjacent areas? ______________________

______________________

______________________

**Exact location.**

Why is St. Louis located on the west, and not on the east side of the river? ______________________

______________________

______________________

Why have no extensive suburban districts been built on the east side? ______________________

______________________

What was the influence of the Cuyahoga River in determining the exact site of the early Cleveland? ______________________

______________________

Why has the city grown more to the east and west than to the south? ______________________

______________________

______________________

What advantage does Denver derive from being on the South Platte River? ______________________

______________________

______________________

What advantage from being near the base of the mountains rather than farther out on the plains? ______________________

______________________

______________________

**Environs of cities.**

What effect has the presence of a city on the direction of the main roads in the surrounding region? ______________________

______________________

______________________

Which, St. Louis or Cleveland, is the objective point of the greatest number of railway lines?

---------------------------------------------- What does this suggest as to the relative importance of railway transportation to the commerce of these two cities? ----------------

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From what directions do most railway lines enter Denver? ------------------------------

------------------------------------------------------------ Why so few from the west?

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Why are there generally many short roads, numerous houses, and small towns in the immediate vicinity of large cities? ------------------------------------------------

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What is the nature of the agricultural products raised on farms near large cities?

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What is the significance of the many short, canal-like branches which extend from Clear Creek and Ralston Creek near Denver?------------------------------------------------

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Write a short paragraph, stating some of the important factors which influence location and growth of large cities, and the effect of the presence of the cities on the surrounding country. ------------------------------------------------------------------

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## XXXVIII. — THE FOLDED APPALACHIANS

**Materials.** **For Each Student. — The contour map of the United States. The Monterey (Va.-W.Va.) sheet, the Delaware Water Gap (Pa.-N.J.) sheet. Colored pencils.**

**Purpose.** *To study a mountain region whose topography is the result of the upfolding of sedimentary rocks, and their later denudation.*

**Introductory.** True mountains are either regions where rocks which were once horizontal have later been folded, faulted, and metamorphosed; or regions in which the rocks are crystalline in character, and generally with a very complex structure. These crystalline rocks often constitute a core underlying mountains made of folded sediments, and are exposed to weathering and denudation only after the overlying masses have been worn away.

The Appalachian mountains are interesting in that they include both types: (1) mountains composed of folded sediments; and (2) mountains which are made up wholly of crystalline rock. Moreover, the most eastern belt of the Appalachians consists of crystalline mountains which have been worn down until only their roots remain, and their surface resembles a plain in topography.

This exercise is a study of the western belt of the Appalachian Mountains, which are made up of folded and then denuded sedimentary strata. (Text-book, pp. 101–105.)

**Location and extent of the Folded Appalachians.** Figure 21 shows the province of the Folded Appalachians, marked "Folded Appalachians." Plot the outlines of the Folded Appalachians on your contour map of the United States.

What parts of what states are included in this province? ____________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

What is the general trend of these mountains? ____________________

____________________ How do you account for the fact that they do not appear in the Mississippi Valley, but reappear in Arkansas? ____________________

____________________________________________________________

____________________ Estimate the length of the whole system. ____________________ What is its average width? ____________________ What proportion of the area of the United States east of the Mississippi do the Folded Appalachians constitute? ____________________

Appalachian Ridges on the Monterey (Va.-W.Va.) Sheet

On a Line from Southeast to Northwest across the Map

| No. | Name of Ridge | Elevation | No. | Name of Ridge | Elevation |
|---|---|---|---|---|---|
| 1 | Mill Mountain | 2500 ft. | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

If they are so narrow, and occupy so small a relative area, why is it that they have so much importance, as compared to plains regions, in the popular mind? ____________________________

________________________________________________________________________________

______________________________________________________________ What is the average (approximate) elevation of the Folded Appalachians as shown by the contours on the United States map? ______________________

With red pencil color in (with parallel ruled lines extending from northeast to southwest) the province of the Folded Appalachians. Fill in a legend square, as indicated on the diagram map, and mark it Folded Appalachians.

**Study of a typical area in the Folded Appalachians.**

Locate the Monterey (Va.-W.Va.) sheet on your United States map and outline its area in ink. Letter in the name of the sheet. What is the most pronounced topographic feature of the Monterey sheet? ______________________________________________ What is the general trend or direction of the ridges? ______________________________________________ Starting at the southeast corner, and following a diagonal line to the northwest corner of the map, set down in the table on page 309, and in order, the names of the ridges you cross and the elevation of their tops.

In which part of the area are the ridges highest? ______________________________________________

Where are they lowest? ______________________________________________ What is the nature of the variation in elevation shown by the intervening ridges? ______________________________________________ If the valleys were all filled up to the level of their bounding ridges, what would be the topography and slope of the country?

______________________________________________

______________________________________________

What is a *peneplain?* (Text-book, p. 102.) ______________________________________________

**Development of the present topography of the Folded Appalachians.**

Just before the last great mountain uplift (in Tertiary time) the province of the Folded Appalachians was probably a plain, having a general slope from northwest to southeast. Although the surface of the plain was comparatively smooth, the rock structure beneath the surface was made up of great folds of rocks varying very much in the degree of their resistance to weathering and denudation.

Make a cross section along a line between the towns Clover Creek and Mill Gap. Let one section of the cross-section paper equal 100 feet in the vertical scale. What would be the direction of flow of the principal streams on a plain sloping as stated above? ______________________________________________ Would this direction of flow be parallel to or across hidden folds? ______________________________________________
Would the valleys of such streams be widened most rapidly where the folds had brought hard rocks near the surface, or where they had brought up soft rocks? ______________________________________________ Which tributary valleys would be cut most rapidly, those flowing along the hard surfaces or the soft? ______________________________________________ What kind of rocks (hard or soft) do the present ridges mark? ______________________________________________ Why are the valleys between ridges so wide as compared to the ridges themselves? ______________________________________________ Name several places where the streams have cut across the ridges. ______________________________________________ Why are their valleys so narrow at these points? ______________________________________________

What is a *water gap?* (Text-book, p. 103.) ______________________________________________

Why are the main streams now flowing southwestward, between the ridges, instead of flowing to the southeast in accordance with the former slope of the plain?

**Human occupation.**

What are the main lines of travel in this region, as indicated by the direction of the roads and the location of the towns? Where do roads cross the ridges? What reasons can you suggest for the general absence of railroads? Examine the Delaware Water Gap sheet. Where do the railroads cross the Kittatinny Range? Why is this water gap more important as a transportation route than those on the Monterey sheet? Examine your United States contour map. What other large streams have cut across the Folded Appalachians?

Why have these large water gaps been so important in the history and development of the United States?

# XXXIX.—THE CRYSTALLINE APPALACHIANS

Materials. **For Each Student.—The contour map of the United States. The Mt. Mitchell (N. C.-Tenn.) sheet, the Monterey (Va.-W. Va.) sheet. Colored pencils.**

Purpose. *To study the topography and settlement of a mountain region of crystalline rocks in a mature stage of dissection.*

Introductory. The Crystalline Appalachians lie to the east of the Folded Appalachians, and include the highest peaks of the Appalachian system. They were lofty mountains before the Folded Appalachians were formed, and had been so long subjected to denudation that they were worn to a condition of low relief. Then, in the uplift which elevated the region of the folded Appalachians, these crystalline mountains were also reëlevated, and it is to this later uplift that they owe their present height. (Text-book, pp. 298 and 308.)

Location and extent of the province of the Crystalline Appalachians. On your contour map of the United States plot the outline of the province of the Crystalline Appalachians as shown on the diagram map. What important section of the country is almost wholly included within the province of the Crystalline Appalachians ?__________________

________________________________What notable irregularities in the width of this province are apparent ?__________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

In what sections of the province are the greatest elevations ?________________________________

__________________________________________________________Which section has the lowest altitudes ?________________________________________________How does the amount of elevation affect the density of settlement as indicated by the cities ?______________________________________

______________________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

Color in, with red pencil (using crosses as indicated on the legend square of the diagram map), the province of the Crystalline Appalachians. Fill in the proper legend square and mark it Crystalline Appalachians.

Study of an area in the Crystalline Appalachians. The Mt. Mitchell, (N. C.-Tenn.) sheet is chosen to illustrate the topography of the Crystalline Appalachians. Locate the position of this sheet on your contour map of the United States and outline its area with ink. Letter in the name of the sheet.

What pronounced difference in the distribution and character of summit areas is apparent on comparing the Mt. Mitchell and the Monterey sheets? ______________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

What is the highest elevation shown on the Mt. Mitchell sheet? ______________________________

____________________ What is the elevation of the lowest peaks? ______________________________

______________________________________________________________ Is there any regularity in the distribution of peaks of a certain elevation? ______________ What reasons can you suggest to account for this? ______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

How does the size of the streams shown on this sheet compare with those on the Monterey sheet? ______________________________________________________________

______________________________________________________________

______________________________________________________________

Why should the Mt. Mitchell region be a divide area? ______________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Make a cross section along a line (N. W. and S. E.) between Laurel Knob and Big Tom Wilson's, crossing Mt. Mitchell. Let one section of the cross-section paper equal 100 feet in the vertical scale. Compare this cross section with the one from the Monterey sheet.

What difference in the width of the valleys and ridges is shown? ______________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

**Human occupation.**

How do the courses of the roads in this region compare with those shown on the Monterey sheet? ____________________

Why have the roads on the Mt. Mitchell sheet so many short, sharp turns? ____________________ How does the topography influence the course of the railroad? ____________________

Why has this region extensive forests? ____________________ As indicated by some of the place names on the map, what kinds of timber grow here? ____________________

What is the most important town on the Mt. Mitchell sheet? ____________________ In a general way (as 1000, 2000, etc.) estimate the number of its inhabitants. ____________________ Why are there no more important towns in the area? ____________________

Suggest a reason why the New England section of the Crystalline Appalachians has more important towns. ____________________

## XL. — THE APPALACHIAN PIEDMONT AREA

**Materials.** **For Each Student. — The contour map of the United States. The Farmville (Va.) sheet, the Mt. Mitchell (N.C.-Tenn.) sheet. Colored pencils.**

**Purpose.** *To study the topography of a very old mountain region, and its adaptation to settlement and agriculture.*

**Introductory.** The rocks underlying the Piedmont Area are crystalline, and are complexly folded and faulted. They vary greatly in structure and hardness; but the region has been so long denuded that its summits have all been worn down to a low relief, and its drainage system is perfectly developed. More recently there has been a slight elevation of the region, rejuvenating the streams. Over the hard crystalline rock lies a thick mantle of residual soil, giving opportunity for agricultural development. The region is one which was occupied and settled very early in the history of the country. (Text-book, p. 307.)

**Location and extent of the Piedmont Area.** On your contour map of the United States plot the outline of the Piedmont Area as shown on the diagram map. Why is the Piedmont Area most important in the Southern States?

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What province does it adjoin on the east? ______________________

What line separates the two provinces? ______________________
What important crop is raised on both the Piedmont and the Coastal Plain provinces?

______________ By (approximately) how much do these two provinces differ in general

elevation? ______________________

What similarity of topography have they? ______________________

______________________ What is the rock structure which underlies each?

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Color in lightly and uniformly, using red pencil, the area of the Piedmont Province as you have outlined it on your United States map. Fill in the proper legend square and mark it Appalachian Piedmont.

**Study of a typical section of the Piedmont Area.**

Locate the position of the Farmville (Va.) sheet on your United States map and outline its area with ink. Letter in the name of the sheet.

What is the nature of the topography shown on the Farmville sheet? ________________

____________________________________________________________

____________________________________________________________

____________________________________________________ What region previously studied does it most resemble? ______________________________

______________________________ How do you account for this similarity?

____________________________________________________________

____________________________________________________________

Why should this region, which is so like a plain, be called an old mountain region?

____________________________________________________________

____________________________________________________________

____________________________________________________________

The topography of the Farmville sheet was once as rugged as that of the Mt. Mitchell sheet. What can you say regarding the amount of time which must have elapsed since it had such a topography? ______________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

State why the Piedmont Area is called a peneplain. ______________________________

____________________________________________________________

____________________________________________________________

______________________________ What is a *monadnock*? (Text-book, p. 298.)

____________________________________________________________

____________________________________________________________

What example of a monadnock do you find on the Farmville sheet? ______________________________

______________________ How many feet does the Appomattox River descend within the area of the map? ______________________ Why has it such a meandering course? ________________

____________________________________________________________

Why are the small tributary streams eroding their valleys?

**Human occupation.** What is the pattern of the roads in this region?

Does it coincide with that of the drainage lines? Does it coincide with the divides? Why?

What indication do the number, size, and location of the towns (individual houses are not shown on this sheet) and the number of the railroads give that this is a rich agricultural region?

Write a short paragraph describing the nature of the country, with respect to topography, agriculture, and drainage conditions, that you would see looking from an elevated point, like Willis Mountain.

## XLI. — THE LAURENTIAN HIGHLANDS

**Materials.** **For Each Student. — The contour map of the United States. The Lake Placid (N.Y.) sheet. Colored pencils.**

**Purpose.** *To study the topography of the old crystalline mountain areas known as the Laurentian Highlands; and the utilization of the Adirondack portion of these as a vacation and resort country.*

**Introductory.** To the north of the eastern part of the United States is found a great area of crystalline rock, known as the Laurentian Highlands, which is considered to be made up of some of the oldest rocks of the earth's crust. The Lake Superior Highlands and the Adirondack Mountains are outlying masses of these Laurentian Highlands, which at these points project into the territory of the United States. (Text-book, pp. 107 and 302.)

**Location and extent of the Laurentian Highlands.** Outline, on your contour map of the United States, the areas of the Laurentian Highlands, as shown on the diagram map.

What is the relative importance of the Laurentian Highlands in the United States with respect to the amount of territory they comprise? ------------------------------------------

------------------------------------------ Why does their location further lessen their importance? ------------------------------------------

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What well-known city is situated in the Lake Superior Highland region? --------------------

To what conditions does this city owe its importance? ------------------------------------------

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------------------------------------------ Why was Lake Champlain, in the eastern part of the Adirondacks, so important in the early history of the United States?

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On your United States map color in with red pencil (using circles as indicated on the legend square of the diagram map) the areas of the Laurentian Highlands in the United States as you have outlined them. Fill in the proper legend square.

**Study of a section of the Adirondacks.**

Locate the position of the Lake Placid (N.Y.) sheet on your United States map, and outline its area with ink. Letter in the name of the sheet. What is the shape and arrangement of the mountain masses shown on this sheet? ______________________________

______________________________

______________________________

______________________________

______________________________ How do they differ in shape from the Folded Appalachians? ______________________________

______________________________

______________________________

______________ From the Crystalline Appalachians? ______________________________

______________________________ Which is the highest mountain shown on this sheet, and what is its elevation? ______________________________

What is the elevation of several other important peaks? ______________________________

______________________________ What do the contour lines show as to the nature of the outline of the mountains, — are they sharp and rugged or smooth and flowing? ______________________________ What does this condition indicate as to the age of the mountains? ______________________________

______________________________ What is the evidence on this point of the number and shape of the valleys on the mountain slopes? ______________________________

______________________________

______________________________

______________________________ How may differences in rock account for the wide valleys between the mountains? ______________________________

______________________________

______________________________

______________________________ What is the elevation of the mountains as compared to the approximate general elevation of the wide valleys between them? __________

______________________________

Do the mountains appear high or low? How do you explain the presence of so many lakes and swamps in a mature mountain region?

If the swamps were formerly lakes, what must have happened to them since?

**Human occupation.**

What do you observe as to the density and distribution of the settlement of this region?

Why are the roads so comparatively numerous in this mountain region?

Near what great centers of population are the Adirondack Mountains?

What is the bearing of this fact on its development as a resort region?

What is the attraction of the mountains for city people?

What recreation and sport do the lakes and rivers afford?

Why is there an especially large settlement around Mirror Lake and Lake Placid?

Write a short paragraph summarizing the attractions of the Adirondack Mountains as a resort country.

## XLII. — THE ROCKY MOUNTAINS

**Materials.** **For Each Student. — The contour map of the United States. The Saw Tooth (Idaho) sheet. Colored pencils.**

**For General Class Use. — A wall map of the United States showing railroads.**

**Purpose.** *To gain an appreciation of the topographic features of the Rocky Mountains, and of the manner in which the presence of ores and open valleys in the mountains has affected their settlement.*

**Introductory.** The Rocky Mountains constitute the most easterly member of the Western Cordillera, a general term given to all the mountainous section of the United States which lies, for the most part, west of the 105th meridian. Because of its physiography, the Western Cordillera, as a whole, is a sparsely settled region; but local conditions, in places, attract a comparatively large population. (Text-book, pp. 106–107, and 314–315.)

**Location and extent of the Rocky Mountain province.** On your United States map outline the area of the Rocky Mountain province as shown on the diagram map.

What is the north-south length of the Rockies? ______________________________________

_______ How do they compare in this respect to the Appalachians? ______________________

_____________________________________________________________ What other factors

make the Rockies a more complete barrier to travel than the Appalachians? _____________

______________________________________________________________________ By consulting the wall map of the United States, locate and plot on your United States map the route followed by the transcontinental railroads in crossing the Rockies. As shown by the topography on your United States map, what factors determine the location of these routes?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

How has the presence of the railroads affected settlement in the Rockies? ______________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________ What important cities are located on these routes? ____________________

____________________

____________________

____________________

____________________ Color in, with red pencil (using the angle symbol shown in the legend square), the province of the Rocky Mountains as you have outlined it on your map. Fill in the proper legend square and mark it Rocky Mountains.

**Study of an area in the Rocky Mountains.**

Locate the position of the Saw-Tooth (Idaho) sheet on your map of the United States, and outline its area with ink. Letter in the name of the sheet.

What is the approximate general elevation of this area? ____________________

____________________ What are the elevations of some of the higher peaks? ____________________

____________________

____________________

____________________ What are the elevations of the bottoms of the larger valleys? ____________________

____________________ As indicated by these conditions, do the individual ranges and peaks constitute the mountain uplift, or does the region as a whole? ____________________

____________________ By what processes are the lesser ranges and peaks developed? ____________________

____________________

____________________

____________________

____________________ Does the topography of this region indicate young, mature, or old conditions?

____________________ Describe the topography of the country as it would appear to an observer stationed on the summit of Big Peak. ____________________

____________________

____________________

____________________

____________________

What evidence indicative of former glaciation of this region do you note?

In what portion of the map are lakes especially conspicuous?

Where else do very small lakes occur?

What is the significance of the occurrence and location of these smaller lakes?

How might deposits from glacial streams account for the wide, level-floored valley in the northern part of this area?

**Human occupation.** Locate the one road of the area which continues unbroken across one of the mountains. How many feet must one climb between Galena and the summit of the divide?

In how many miles? Why has the road in this section several very sharp turns?

What two sections of the area have invited settlement?

What was the reason for the settlement in each case?

Suggest a reason why the mines in the southeast section are closely grouped.

What is the probable method of transportation between the Silver Star mine and the King of the West mine?

About how many square miles of land are available for agriculture in the large valley to the north? What is the nature and importance of Rocky Mountain Parks? (See Text-book, p. 95.)

Write a short paragraph summarizing the significance of the Rocky Mountains as a barrier to transportation and travel, and the reasons for their settlement in isolated areas.

## XLIII. — MOUNTAIN GLACIERS AND THE CONTINENTAL DIVIDE

**Materials.** **For Each Student. — Contour map of the United States. Chief Mountain (Mont.) sheet.**

**Purpose.** *To study the topography of a mountain region having existing glaciers, and the evidence it presents of former more extensive glaciation.*

**Introductory.** The mountain region shown in this sheet has topographic characteristics of a stage between youth and maturity. The normal topography of weathering and stream erosion has, however, been modified very much by glacial erosion. The glaciers which exist to-day are but remnants of former much greater ones, as is indicated by the topography. The region has a further interest in that it is along the line of the Continental Divide. This map, and those used in the exercises on the Colorado Plateau and Canyon, and the Yosemite, are commended for their excellence of topographic expression; they illustrate the possibilities of contour maps in expressing land forms. (Text-book, pp. 137–139, 141–142.)

**Location of the area.** Locate the position of the Chief Mountain (Mont.) sheet on your contour map of the United States, and outline the area with ink. Letter in the name of the sheet.

In what physiographic province is the Chief Mountain region? _________________________

____________________ What is the latitude of the northern edge of the sheet? ______________

______________ What boundary line does it mark? _________________________________________

**Continental Divide.** Examine the Chief Mountain sheet. What determines the line of the Continental

Divide? ________________________________________________________________________

What is the eventual destination of the precipitation that falls on the eastern side of the

divide? ________________________________________________________________________

On the western side? ___________________________________________________________

What is the effect of the presence of forests on the rate of the *run off* of rain and snow water

from a land surface? __________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

________________________ Why has this area been made a "Forest Reserve"? _______________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

Why is the presence of forests desirable at the headwaters of streams?

**Existing glaciers.**

Name the larger glaciers mapped in this area.

What is their general distribution?

On which side of the divide are the greater number?

What explanation can you offer to account for this fact?

Which glacier is largest?

What is its length in miles and fractions of a mile?

Its width?

How does this compare with the dimensions of Alpine glaciers? (See Text-book, p. 137.)

What is the lowest altitude to which the glaciers descend?

How many of the glaciers descend to about the 7500 foot level?

What reasons can you suggest for this uniformity in the altitude of their melting ends?

**Evidence of former greater glaciation.**

What provinces of the United States, which you have previously studied, were characterized by the presence of many lakes? ______________________________

______________________________

______________________________

______________________________ What is the significance of the many lakes in this region? ______________________________

______________________________

Describe the shape of the depressions occupied by the existing glaciers. ______________________________

______________________________

______________________________

______________________________

What is a *cirque?* (See Text-book, p. 142.) ______________________________

______________________________

______________________________

______________________________ Identify other cirques in this region besides those occupied at present by glaciers. ______________________________

______________________________

______________________________

Make a cross section of the valley of Swiftcurrent Creek (emptying into the Sherburne Lakes) on a line (N.W.-S.E.) between Point Mt. and Appekunny Mt. Let one division of the cross-section paper equal 200 feet in the vertical scale. What is the shape of this valley cross section? ______________________________

______________________________

How does it differ from the shape of the cross sections of valleys in the Appalachian Plateau?

______________________________

______________________________

What is the significance of a U-shaped valley? ______________________________

______________________________

______________________________

Locate and name other valleys on this sheet which have similarly shaped valleys.

What are *hanging valleys ?* (Text-book, p. 142.)

Why are waterfalls present at the mouths of hanging valleys ?

Locate examples of hanging valleys; for example, in St. Mary River valley.

What is the evidence of the presence of lakes, cirques, the U-shape of the valley cross sections, and hanging valleys on the question of the former greater extension of the glaciers ?

## XLIV. — THE COLUMBIA LAVA PLATEAU

**Materials.** **For Each Student. — The contour map of the United States. The Spokane (Wash.-Idaho) sheet. The Denver (Colo.) sheet. Colored pencils.**

**Purpose.** *To study the topography and settlement of the Columbia Lava Plateau.*

**Introductory.** The region of the Columbia Lava Plateau is made up of great sheets of lava, which, in a comparatively recent geological period, welled up from fissures in the earth's crust, and spread over the country as immense floods of molten rock. Since then the plateau surface has been much dissected by denudation; and a thick mantle of residual soil covers large portions of its area. (Text-book, pp. 125–126.)

**Location and extent of the area.** On your contour map of the United States plot the area of the Columbia Lava Plateau as outlined on the diagram map. What states are partly included in this province? __________

__________________________________________________ What range of altitude do you note? __________________________________________

________________________________ What portion of the province is most plateau-like in its topography? __________________________________________

________________ Why is the portion of the province which adjoins the course of the Columbia River most dissected? __________________________________________

__________________________________________________

__________________________________________________

Color in, with brown pencil (using the symbol indicated in the legend square on the diagram map), the province of the Columbia Lava Plateau. Fill in the proper legend square and mark it Columbia Lava Plateau.

**Study of a section of the Columbia Lava Plateau along its eastern margin.** Locate the position of the Spokane (Wash.-Idaho) sheet on your map of the United States, and outline its area with ink. Letter in the name of the sheet.

What physiographic province borders the Columbia Lava Plateau on the east? ________

____________________________________ What portion of the area mapped on the Spokane sheet is to be included in the Rocky Mountain Province? ________________________________

____________ What was the approximate general altitude of this part of the Columbia Lava Plateau before dissection, as shown on this sheet? ______________________ What are the physiographic characteristics of Five Mile Prairie? ________________________________

What physiographic term would you apply to it? Locate other similar areas.

Are mesas most common in a region of little or great rainfall? In regions of horizontal or of inclined strata? What does this indicate regarding the position of the strata and the rainfall conditions on the Columbia Lava Plateau?

Account for the presence of so many permanent streams in this section of the Columbia Lava Plateau.

**Human occupation.** Is there more agricultural settlement on the level areas, such as the mesa tops, or on the valley slopes? The soil of the Columbia Lava Plateau is residual, — that is, it is formed by the decay of the lava rocks, and rests directly on them. Why should there be a greater depth of this soil on the uplands than on the valley sides?

What is the significance of the location of Spokane with reference to the Spokane Valley as a highway?

Remembering that the Great Northern is a transcontinental railroad, what influence has the location of Spokane had on the course of railroads?

There is a waterfall in the Spokane River where its course passes through Spokane. What is the bearing of this fact on the exact location and growth of Spokane?

Write a short paragraph contrasting and comparing the sites and environs of the cities of Denver and Spokane.

## XLV. — THE GREAT BASIN REGION

**Materials.** **For Each Student. — The contour map of the United States. The Granite Range (Nev.) sheet. Colored pencils.**

**Purpose.** *To gain an appreciation of the physical geography of the Great Basin Region.*

**Introductory.** The Great Basin is a region of interior drainage. (Text-book, p. 324.) Its area is encompassed by more elevated mountain and plateau barriers, and the precipitation of the present climate is not sufficient in amount to enable the basin to fill up and overflow at some point on its rim. In recent geological times, however, the climate of the Great Basin Region was more humid, and a large lake, Lake Bonneville (Text-book, pp. 163–164) occupied a great extent of its area, the mountain ranges projecting as islands above its level.

A region to the southeast marked "Open Basins" has similar conditions to those of the Great Basin, except that most of the drainage escapes to the sea.

**Location and extent of the Great Basin.** On your contour map of the United States plot the outline of the area of the Great Basin as indicated on the diagram map. What state and parts of states does it include within its limits? ____________________

____________________ What is the general nature of its topography? ____________________

____________________

____________________

____________________ What is the most important stream within the Great Basin? ____________________

____________________ Where is its source? ____________________

____________________

____________________ Its mouth? ____________________

____________________ In what respects are the courses of the smaller streams similar to that of the Humboldt River? ____________________

____________________

____________________ What is the general trend of the mountain ranges?

____________________

Figure 301 of the Text-book is a map of the extent of the former Lake Bonneville. Outline its extent, approximately, on your contour map of the United States, using a dotted line. Mark the area, thus inclosed, Lake Bonneville.

Where was the probable region of outflow of former Lake Bonneville, as indicated by the contour lines on your United States map? ____________________

____________________ What approximate proportion of its area does the present Great Salt Lake occupy? ____________________ What does the location of Great Salt Lake indicate as to the deepest portion of the former Lake Bonneville? ____________________

____________________ Suggest a reason why the main settlement of the Great Basin region centers about the present lakes within its area. ____________________

____________________

____________________

Color in, with yellow pencil (using ruled lines as indicated in the legend square of the diagram map), the area of the Great Basin region as you have outlined it on your United States map. Fill in the proper legend square and mark it Great Basin.

**Study of a typical area within the Great Basin.**

Locate the position of the Granite Range (Nev.) sheet on your map of the United States and outline its area in ink. Letter in the name of the sheet.

What three prominent features make up the physiography of this area? ____________________

____________________

____________________ What is the general trend of the mountain ranges? ____________________

The Selenite Range is typical of many of the Basin Ranges. What is the approximate length of the Selenite Range? ____________________ Its elevation? ____________________

How do these dimensions and its isolation compare with ranges of the Rocky Mountain region?

____________________

____________________

Where are the sources of the small streams? ____________________

____________________ Why do they disappear when they reach the level places? ____________________

____________________

____________________

____________________ What becomes of the dissolved material they are carrying? (Text-book, pp. 87 and 169.) ____________________

Where are such deposits being formed in this area?

What becomes of the sediment they carry?

What suggestion does this give as to the origin of the flats between the mountain ranges?

What would be the bearing of the former greater extent of Pyramid Lake on the question of the origin of these flats?

**Human occupation.**

Why are there no cities within this area?

What one industry is indicated by a place name?

Why should salt be found in such a situation? (Text-book, p. 163.)

## XLVI. — THE COLORADO CANYON AND PLATEAU

**Materials.** **For Each Student.** — **Contour map of the United States. The Bright Angel (Ariz.) sheet. Colored pencils.**

**Purpose.** *To study the erosional work of a great river, cutting through thick horizontal strata in an arid plateau region.*

**Introductory.** The Colorado River has its source among, and is fed by, the melting snows of the mountains of the lofty central Rocky Mountains, being formed by the junction of the Green and the Grand rivers. The river waters are abundantly supplied with sediment by the weathering of the mountain slopes, yet are not overloaded. Consequently, in flowing across the plateau to the south and west, the river has been able, by means of its rock tools, to carve the remarkable canyon which bears its name. The Colorado Plateau Province itself consists of a series of rock platforms, level in topography and separated one from the other by fault and weathering escarpments. (Text-book, pp. 81–82 and 322–323.)

**Location and extent of the province.** On your contour map of the United States plot the outline of the area of the Colorado Plateau as shown on the diagram map.

What states lie partly in this province ? ______________________________

______________________________________________________________

______________________________ What is its approximate elevation ?

______________________________ What is the nature of the topography of the Colorado Plateau, excluding the Canyon ? ______________________________

______________________________________________________________

Approximately how many feet does the Colorado River descend between the point of junction of the Green and Grand rivers and the point where it first touches the Nevada state boundary line ? ____________________ About how long is this portion of its course ?

____________________ How does its average descent per mile compare with that of the Mississippi below Cairo? (See exercise on Mississippi Flood-plain and Delta Province.)

______________________________________________________________

______________________________________________________________

Why has the Colorado River such great erosive power ? ______________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

On your contour map of the United States color in with green pencil (using the symbol shown in the legend square) the area of the Colorado Plateau. Fill in the proper legend square and mark it Colorado Plateau.

**Study of the Grand Canyon and adjacent plateau areas.**

Locate the position of the Bright Angel sheet and plot the outline of its area on your United States map. Letter in the name of the sheet. What is the general direction of slope of the Colorado Plateau as shown by the areas named the Kaibab Plateau to the north of the Canyon, and the Coconino Plateau to the south? ________________________________________

________________________________________ What effect has this had on the course of small streams on the plateau surface? ________________________________________

________________________________________

How may these conditions account for the longer slope of the north side of the Grand Canyon at this point? ________________________________________

________________________________________

________________________________________

________________________________________

What is the scale of the Bright Angel sheet? ________________________________________
What is the approximate width of the Grand Canyon on a line directly north from Grand Canyon station? ______________________ What is the greatest depth of the canyon shown? ______________________ How does this width and depth compare with the dimensions of the Niagara Gorge? ________________________________________

________________________________________

________________________________________

What condition of slope is indicated where the contour lines are run together to form a ribbon of solid brown? ________________________________________

______________________ What kind of rock layers, hard or soft, would be marked by vertical cliffs? ______________________ Account for the isolated monuments, like the Isis Temple, left standing as outliers of the canyon wall. ______________________

________________________________________

________________________________________

________________________________________

Name various illustrations of stages in the process of formation of such buttes and mesas.

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In what kind of rock is the river cutting at present, as indicated by the name of the inner gorge? ------------------------------ Why is there no alternation of vertical cliffs and gentler talus slopes in this inner gorge? ------------------------------ What is the nature of the river's flow here, as shown by the conventional sign? ------------------------------

------------------------------------------------------------------------

**Human occupation.**

How many houses are mapped on this area? ------------------------------ What two factors account for this very sparse settlement? ------------------------------

------------------------------------------------------------------------

------------------------------------------------------------------------

------------------------------ Why is a railroad built to the Grand Canyon?

------------------------------------------------------------------------

Why is this canyon an even greater barrier to travel than a high mountain range? ---------

------------------------------------------------------------------------

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Write a short paragraph telling what you would expect to see if you were standing at Yavapai Point and looking out over, and down into, the Grand Canyon.

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## XLVII. — THE YOSEMITE VALLEY

**Materials.** **For Each Student. — The contour map of the United States. The Yosemite (Cal.) quadrangle. Map of the Yosemite Valley, California.**

**Purpose.** *To gain an appreciation of the setting, scenic magnificence, and topographic relations of the Yosemite Valley.*

**Introductory.** The four preëminent scenic resources of the United States are Niagara Falls, the Grand Canyon of the Colorado, the Yellowstone National Park, and the Yosemite Valley. Three of these, and the fourth in part, owe their origin and interest to the results of the erosive work of water, active either as a running stream or in the form of glacial ice. The features of the Yosemite Valley are the resultant of both ice and water work on a jointed, granite rock. During the Glacial Period huge glaciers radiated from the higher summits of the Yosemite region, and, moving downward toward the lowlands, scoured out and differentially eroded their valley channels, leaving the smaller valleys hanging at their mouths, far above the floor of the main valleys. As a result of this differential glacial erosion, waterfalls were born when the valleys were eventually freed of ice, so that the streams could again flow.

**Location of the Yosemite Valley.** Locate the position of the Yosemite sheet on your contour map of the United States, and outline its area with ink. Letter in the name of the sheet.

As indicated by the contours on the United States map, why is the Yosemite Valley said to be in the "High Sierras"? ____________________

____________________

____________________

____________________ What is the approximate general elevation above sea level of the summits in the Yosemite region as shown on the Yosemite quadrangle? ____________________ Of the valley bottoms? ____________________ Explain the absence of railroads in this region. ____________________

**Topographic relations.** In what respect does the Yosemite Valley differ markedly from other valleys in the region? ____________________

____________________

____________________

What other valley has similar features on a lesser scale? ____________________

____________________ What distinct difference in the valley form of the Hetch Hetchy Valley and the Grand Canyon of the Tuolumne (both of the Tuolumne River) do you note?

____________________

Which of these forms is most characteristic of glacial erosion?

Is the form of the Yosemite Valley typical of glacial or stream erosion?

Examine the map of Yosemite Valley. What particularly striking topographic forms are indicated by the many areas of crowded contour lines?

How high is the cliff of El Capitan? Describe the Half Dome as to height above base, shape, and steepness of sides.

What are joint planes? (Text-book, p. 38.)

How would the presence of such joint planes in massive granite rock aid in the development of precipices?

How would such jointing in the rock affect the erosive action of a glacier moving down the valley of the Merced River?

What evidence of such action is apparent on the map?

Why would a large valley glacier erode deeper than a small one?

Since there were glaciers in the valleys of both the Merced River and the Yosemite Creek, why is the valley floor of the latter now so high above that of the Merced River?

What is the height of the upper Yosemite Falls?

In what way have weathering and erosion since the Glacial period combined to give the Merced River a flat valley floor?

What has been the effect of this on the course of the river?

Why has this region been made a National Park?

Write a short paragraph telling what scenic and physiographic phenomena you would anticipate seeing on a visit to the Yosemite Valley.

## XLVIII. — MT. SHASTA AND SURROUNDING REGION

**Materials.** **For Each Student. — The contour map of the United States. The Shasta (Cal.) and the Shasta Special sheets.**

**Purpose.** *To study a volcanic cone and a region of former volcanic activity.*

**Introductory.** Mount Shasta is the cone of a volcano which has been dormant or extinct for many centuries. In the region adjoining Mt. Shasta there is other evidence of former volcanic activity. Since the cessation of eruptions from Mt. Shasta, erosion and weathering have to some extent modified the original outline and contour of the cone. (Text-book, p. 121.)

**Location of Mt. Shasta.** Locate the position of the Shasta (Cal.) sheet, and outline its area with ink on your United States map. Letter in the name of the sheet. Mark the position of Mt. Shasta with a cross (×).

**Mt. Shasta and the adjoining region.** Examine the Shasta (Cal.) sheet. What is the difference in outline and topography between Mt. Shasta and the adjacent mountain regions? ________________

________________________________________

________________________________________

________________________________________

________________________________ What is the altitude of Mt. Shasta? ____________ How does this elevation compare with that of the highest points in the surrounding region? ________________

________________________________________

________________________ Why is Mt. Shasta a dominating feature of the landscape in Northern California? ________________

________________________________________

________________________________________

Assume the floor of the valley from which Mt. Shasta rises to represent the original level of the country, and on this basis calculate the approximate number of cubic miles of volcanic material which has been ejected to build up the cone. ________________

Shastina, a minor summit to the west of the main Mt. Shasta summit, is a secondary cone. What other near-by mountains are of volcanic origin, as suggested by their form or the names given them? ________________

Topography of Mt. Shasta.

Make a cross section of Mt. Shasta on a line passing through Butteville and Shastina, and extending to the eastern edge of the map. Let one division of the cross-section paper equal 600 feet in the vertical scale. This will give a vertical exaggeration of about four times.

What is the general shape of a volcanic cone as shown by this cross section?

Are its slopes, in general, steep or gentle as compared to other mountains?

Explain why they are so much steeper near the summit.

In what way does the cross section of Shastina suggest that it is a secondary cone?

Topographic details of Mt. Shasta.

Examine the Shasta Special sheet. In what two respects does Mt. Shasta depart from a perfect cone?

Suggest a reason why the shape of the lava flows very much resembles that of the glaciers.

On which side of the cone are valleys developed most markedly? What is the general pattern of the drainage? Suggest a reason for the origin of the buttes on the south side of the cone.

What do the place-names Cinder and Ash suggest as to the material where they occur?

Why should the larger glaciers be on the north side of the cone?

Write a short paragraph summarizing the topographic characteristics of a volcanic cone composed partly of ash and partly of lava.

## XLIX. — PIEDMONT VALLEYS OF THE PACIFIC SLOPE

**Materials.** **For Each Student. — The contour map of the United States. The Cucamonga (Cal.) sheet. Colored pencils.**

**Purpose.** *To study the formation of alluvial fans of large area, and the relation of such fans to the adjacent topography.*

**Introductory.** The mountains of the west coast are still rising, and being, therefore, young mountains, the processes of denudation are very active on their slopes and summits. In consequence, the streams which flow down their slopes carry heavy loads of sediment, and the intermont areas of this region, like the Valley of California, owe their level floors to filling up with this waste from the mountains. (Text-book, pp. 66–68.)

**Location and extent of these regions.** On your map of the United States outline the areas of the larger Piedmont valleys of the Pacific Slope, as indicated on the diagram map. (It is to be understood that there are many other smaller areas of similar conditions in this region.)

Between what mountain ranges are these valleys located? ____________________

________________________________________

________________________________________

________________________________________ What is the approximate

area of each in square miles? ____________________

________________________________________

________________________________________

Color in with blue pencil (using the symbol indicated in the legend square on the diagram map) the areas of the Piedmont valleys of the Pacific Slope. Fill in the proper legend square and mark it Pd. Val. Pac. Slope.

**Study of an alluvial fan on the edge of a Piedmont valley.** Locate the position of the Cucamonga (Cal.) sheet on your map of the United States and outline its area with ink. Letter in the name of the sheet.

What is the nature of the country shown in the northern part of the Cucamonga sheet?

________________________________________

In the southern part? ____________________

____________________ What is the approximate average slope per mile of the stream in Cucamonga Canyon between its source and the point of its disappearance at the edge of the

mountains? ____________________ What is the average slope per mile of the country for five miles to the south of the mountain base? ________________

________________________________________ How do these two slopes compare in steepness?

________________________________________________________________________________

________________________________________________________________________________

Over which slope could the stream carry the greater amount of sediment? ________________

________________________________ Why would such a mountain stream be abundantly supplied with sediment? ________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

____________________ Why could this sediment load not be carried far beyond the edge of the mountains? ________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

_____________ What portion of the load (*i.e.* what kind of material) would be deposited first? ______________________________________________ Why does the stream disappear at a short distance beyond the mountains? ______________________________________________

________________________________________________________________________________

________________________________________________________________________________

______________________________________________ Account for its reappearance farther south.

________________________________________________________________________________

________________________________________________________________________________

What is the significance of the dotted brown patches and streamers? ________________

________________________________________________________________________________

________________________________________________________________________________

____________________________________________________________________ Describe the conditions that you think would be observed in this region at a time when a great flood poured out from the canyon. ____________________________________________________________

Why are such deposits as these called *alluvial fans ?*

On what portion of their surface are their slopes steepest? Why there?

Why do the contours bend farthest outward directly opposite the stream mouths?

Is the climate on the alluvial fans arid or humid?

Why, then, is there such dense settlement?

What is the source of the water that these communities need?

**Human occupation.**

Give two reasons why the towns are located near the base of the alluvial fans and away from the foot of the mountains.

Write a short paragraph comparing and contrasting the mode of origin and the slopes and topography of a delta and an alluvial fan.

## L. — THE PACIFIC RANGES AND SAN FRANCISCO HARBOR

**Materials.** **For Each Student. — The contour map of the United States. The San Francisco (Cal.) sheet. The Tamalpais (Cal.) sheet. Colored pencils.**

NOTE. — It will be well to mount the two topographic sheets on cloth so that they form one continuous map.

**Purpose.** *To study the physical geography of a mountain region along an ocean coast.*

**Introductory.** The mountain systems of the Pacific Slope, west of the Columbia and Colorado Plateaus and the Great Basin, are still being uplifted and, in consequence, have the topography and characteristics of very young mountains. The uplift is not a simple elevation, but is made up of a complex of movements, both up and down vertically, and including also lateral shifts of the mountain blocks. Those parts of the region which are adjacent to the ocean show the evidence of these movements most clearly, because the ocean furnishes a permanent level, or datum plane. (Text-book, pp. 206, 321.)

**Location and extent of the region.** On your contour map of the United States outline the region of the Pacific Ranges as indicated on the diagram map.

What parts of what states are included in this region? ______________________________

______________________________________________________________________

______________________________________________________________________

What notable differences are there between the Pacific and Atlantic coasts of the United States? ______________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Give a reason why there is no broad coastal plain along the Pacific Coast. ________________

______________________________________________________________________

______________________________________________________________________

How does the total area of all the high mountain provinces of the United States compare (approximately) with the area of the plain and plateau provinces? ______________________

______________________________________________________________________

______________________________________________________________________

Did you, previous to taking this course, conceive the mountain regions of the United States to be wider or narrower than you have outlined them? ____________________

What reason can you give for your answer? ____________________

____________________

____________________

____________________

Color in with red pencil (using the symbol indicated in the legend square of the diagram map) the region of the Pacific Ranges. Fill in the proper legend square and mark it Pacific Ranges.

**Study of a section of the coast of the Pacific ranges.**

Locate the position of the San Francisco and Tamalpais (Cal.) sheets, and outline with ink the area they include. Letter in the names of the sheets.

Have the mountains shown on these sheets a rugged or a gentle topography? ____________________ Have the streams steep or gentle slopes? ____________________ Are the small streams tributary to any large system, or independent? ____________________ What do these facts indicate regarding the topographic age of the region? ____________________

Is the coast line of California, in general, high and rocky, or low and sandy? ____________________ Is it, in general, straight or indented? ____________________ What does such a large irregularity as San Francisco Bay indicate as to the most recent change of land level in this part of the coast? ____________________ How do you account for the flats on which Oakland and Berkeley are built? ____________________

____________________

____________________

What is the origin of the narrow neck of land which cuts off the mouth of the Bolinas Lagoon? ____________________

____________________

____________________

____________________

What does its position indicate as to the prevailing direction of currents on this coast?

**Human occupation.**

Why is San Francisco Bay an exceptionally favorable site on the Pacific Coast for the growth of cities?

How is the site affected by the fact that the adjacent mountains are growing?

Which has the greater number of docks for ships, Oakland or San Francisco?

Suggest a reason why San Francisco, on a peninsula, has grown more than Oakland, on the mainland, which has more direct railroad connections.

What effect has the presence of the cities had on the settlement of the adjacent mountain regions?

Why was a railroad built to the summit of Mt. Tamalpais?

Suggest reasons for the building of several of the difficult mountain roads of the region.

Write a short paragraph citing the factors which make San Francisco Bay a very important harbor.

## LI. — COAST LINE CORRELATION

**Materials.** **For Each Student. — The contour map of the United States. The Boothbay (Me.) sheet. The Barnegat (N.J.) sheet. The Port Orford (Ore.) sheet.**

**For General Class Use. — Mt. Mitchell (N.C.–Tenn.) sheet.**

**Purpose.** *To gain an appreciation of the variation in conditions along the coasts of the United States and the main causes for this variation.*

**Introductory.** There are four general variations in the nature of coast lines, dependent on four variable conditions: Whether the coast line is being elevated or depressed, and whether the coast topography is low, or bold and rugged. The length of time that a given condition has existed also exerts a decided influence in determining the character of the coast line, as do the nature of the adjacent land areas and the exposure to waves and currents.

**Study of a bold, rocky, indented coast.** Locate the position of the Boothbay (Me.) sheet on your contour map of the United States and outline its area in ink. Letter in the name of the sheet. (Text-book, pp. 208-210.)

In what physiographic province is this area located? ________________________________

**Topography.** What was the rock structure of this province, as noted in your previous study? ____________

________________________________________________________________________________

In what respects does the topography of the Boothbay area differ from that of the part of this province previously studied? ________________________________________________

________________________________________________________________________________

________________________________________________________________________________

________________________ Which has the older topography? ________________________________

What is the most notable characteristic of this coast? ________________________________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________ What is the general direction of the extension of the long bays ("Rivers")? ________________________________________________

Are the shores along this coast steep or low? ______________________ What does this suggest as to the depth of the water offshore? ______________________________________________

What is the approximate average elevation of the islands in, and the ridges between, the long bays? ________________________ Are these elevations continuous ridges or isolated knobs? ________________________ Would there be a greater or lesser number of islands if the land surface were raised 50 feet? ________________________ ________ If it were depressed 50 feet? ________________________

How does this apply in explanation of the present conditions along this coast? ________________________

________________________________________________

________________________________________________

________________________________________________

________________________________________________

Why should this be called a drowned coast? ________________________

________________________________________________

________________________________________________

**Human occupation.**

Give reasons why you think this region is attractive as a summer vacation resort. What protection do the deep inlets afford vessels? ________________________

________________________________________________

________________________________________________

________________________ Why are lighthouses necessary? ________

________________________________________________

What does their location suggest as to which is the most important harbor of this part of the coast? ________________________ Give a reason why on this coast of many fine harbors there is no large city. ________________________

________________________________________________

________________________________________________

**Study of a low, sandy coast. Topography.**

Locate the position of the Barnegat (N.J.) sheet on your United States contour map and outline its area in ink. Letter in the name of the sheet. (Text-book, pp. 205 and 212–215.)

In what physiographic province is this area located? ________________________

Is the coast line bold or low? ________________ What is the condition of the valleys of the larger streams? ________________________

Does this suggest recent submergence, or uplift, of the land along this coast?

What would be the effect of a continued movement in the same direction?

In the other direction?

What is the origin of Island Beach?

What is the nature of the small hills on its surface?

Explain why the ocean side of Island Beach is so straight and its land side so irregular.

What do the blue-lined (straight) areas represent? (See Fig. 20.)

What, then, is taking place in the bay between Island Beach and the mainland?

Why is a *hook*, extending westward, formed at Barnegat Light?

What does its position and extension suggest as to the direction of the current which carries the sand supply?

Does the action of the currents and waves tend to straighten a coast line, or make it irregular?

**Human occupation.**

What evidence is given by the map that the water between the mainland and Island Beach is quite shallow?

What kind of return justifies the building of a railroad to this barren sand bar?

Give some reasons why ocean bathing is much more pleasant here than at Boothbay, Me.

Why is this Barnegat shore especially dangerous to navigation?

What recognition of this fact do you find on the map?

Why are the broad mouths of the rivers not available for harbors?

**Study of a bold, regular coast.** Locate the position of the Port Orford (Ore.) sheet on your United States map and outline its area with ink. Letter in the name of the sheet. (Text-book, p. 206.)

**Topography.** In what physiographic province is this area located? ______________________________

What are the general characteristics of that province? ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________ To what extent are they shown on the Port Orford sheet? ______________________________

______________________________

What is the nature of the coast line bordering a region of rising mountains, as here shown? ______________________________

______________________________

______________________________

______________________________

What portion of the coast line shown on this sheet rises directly and steeply from the sea? ______________________________ Which portion has the most extensive coastal plain? ______________________________ How does the presence of the large streams account in part for the coastal plain? ______________________________

______________________________

______________________________

______________________________ What conditions of the topography of the adjacent land areas would lead to a comparatively rapid development of a coastal plain along this coast? ______________________________

______________________________

______________________________

______________________________

What does the direction of the extension of the bars along this coastal plain (and the deflection of the river mouths) indicate as to the direction of the currents along the coast?

How does the presence of the streams tend to maintain openings in the bars?

Account for the lakes along this coast.

**Human occupation.**

What general conditions have prevented a dense settlement along this coast?

Account for the location of Port Orford.

What effect must the mountains have on the future growth of such a seaport?

Why is most of the agricultural settlement found on the northern coastal plain and in the valleys of the larger streams?

Write a paragraph comparing and contrasting the conditions of the coast lines of the three areas studied.

## LII. — SPECIAL TYPES OF LAKES

**Materials.** **For Each Student.** — **The contour map of the United States. The Van Horn (Tex.) sheet. The Crater Lake Special (Ore.) sheet.**

**Purpose.** *To afford the pupil an opportunity to apply the methods of the preceding exercises in making an original interpretation of the features of the above-named sheets, and to gain an incidental knowledge of two types of lake basins.*

**Introductory.** In interpreting the Van Horn (Tex.) sheet, see Text-book, pp. 87 and 169.

For the Crater Lake (Ore.) sheet, see Text-book, pp. 121–122.

Consult the references given above, and then proceed to interpret the two maps to the best of your ability, following the general scheme of the preceding exercises.

# FIELD EXCURSIONS FOR THE SPRING SEASON

## LIII. — EXCURSION TO STUDY GLACIAL PHENOMENA

**Materials.** **For General Class Use. — One or more magnetic compasses.**

**Purpose.** *To study the nature of the evidence of the former presence of glaciers, and to note some of the effects of former glaciation.*

**Introductory.** If the school lies outside the belt of former continental glaciation, this excursion cannot, of course, be undertaken; but if it is situated within the limits of that belt, the probabilities are that several of the topics of this outline can be included in a single excursion. In some regions two or more excursions could be profitably devoted to this study.

**Glacial scratches.** For this part of the excursion it is assumed that the class is taken to a rock exposure on which glacial striations are visible. Is the rock surface between the striations rough or smoothed? ____________ What is the width of the scratches? ____________ Are they straight or irregular? ____________ What is their length? ____________ Describe this rock surface in a few sentences. ____________

What kind of a surface would running water make? ____________ Weathering? ____________ What agency could cause such scratches on a rock surface? ____________ What is the compass direction (approximately) of the scratches? ____________ From what direction did the ice come? ____________ What effect will weathering have on this rock surface? ____________ From the freshness of these *striæ*, what do you conclude as to the recency of the glacial period? ____________

________________________________________

________________________________________

**Bowlders and pebbles.** It is assumed that the class is taken to a place where one or more bowlders of foreign origin may be seen. What is the nature of the bed rock of the region? ________________

________________________________________

________________________________ Of what kind of rock is the bowlder composed? ________________________________

________________________________________

________________ What reason can you give for the fact that such glacial bowlders were given the name *erratic?* ________________________________

________________________________________

________________________________________

________________________ Do you know where rock of this kind is found in place? ____________ Could an ordinary current of water have brought this bowlder? ____________ What agent of transportation could readily carry so large a rock? ________________________ Does the place from which the bowlder has probably been brought agree with the direction indicated by the glacial scratches? ________

**A till bank.** It is assumed that the class is now examining a cut in a deposit of till. In what kind of a water current, rapid or slow, is clay deposited? ________________ In what kind of a water current are pebbles carried and deposited? ________________ When water deposits sediment, is it assorted or unassorted? ________________ Is it stratified or unstratified? ________________ Describe this deposit. ________________________

________________________________________

________________________________________

________________________________________

________________________________________

________________________________ Is it assorted? __________

Is it stratified? ________________ Would water that brought pebbles also deposit clay at the same point? ________________ Why could water not have formed this deposit?

______________________________________________________________________

______________________________________________________________________

Could wind have caused it? ________________ Why? ______________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________ Could ice have formed it?

________________ Write a brief statement of the differences between ice and water as agencies of transportation and deposition. ________________________________________

______________________________________________________________________

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______________________________________________________________________

Write a brief statement giving the proof that this deposit was not made by water, but by ice.

______________________________________________________________________

______________________________________________________________________

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______________________________________________________________________

Examine the pebbles in the till to see if they are all the same kind as the bed rock of the region.

______________________________________________________________________

______________________________________________________________________

Are any of them scratched? ________________ Describe the scratched stones, and tell how they could have been scratched if brought by a glacier. ______________________________

What is the form of stream pebbles?

Are stream pebbles scratched? What light do the scratched stones throw upon the origin of this till deposit?

Write a paragraph stating the evidences that you have seen indicating the former presence of an ice sheet in this region, and the reason for concluding that these phenomena cannot be assigned to other agencies, such as wind or running water.

**Other glacial phenomena.** If other glacial phenomena, such as moraines, drumlins, kames, eskers, or outwash gravel plains are studied, note their position, form, and composition. State their origin, with reasons for the conclusion.

## LIV. — EXCURSION TO STUDY RIVER VALLEY DEVELOPMENT

**Materials.** **For Each Student. — The topographic map of the region, if published.**

**Purpose.** *To study the form and stage of development of a valley in the home region; to interpret its past history; and to gain an appreciation of the probable changes in the future.*

**Introductory.** For the purpose of this excursion a valley of moderate size is better than a large one. (Even a gully in a field would serve for such an excursion, though it would then be necessary to modify this outline.) There would be no disadvantage in going to the same valley as that studied in section XII.

**The valley form.** Where does the stream rise? ________________________________________________

________________________ Where is the mouth? ________________________

________________________________________________ About how long is it?

________________ To what is it tributary? ________________________

About how wide is its valley? ________________ About how deep is the valley?

________________ What is the nature of the divide (sharp, flat, etc.) between this valley and the next one? ________________________ Are the sides of the valley steep or gently sloping? ________________________

________________________ If the sides are different in different parts, state the nature of the difference. ________________________________________________

________________________________________________

________________________________________________

Has the valley form the characteristics of youth, maturity, or old age? ________________

________________________________________ Is there greater or less maturity toward the mouth of the stream? ________________________

**The stream.** About how wide is the stream? ________________ How does this compare with the width of the valley? ________________________________________

________________ Is the stream ever larger? ________________ About how much? ________________________ Are there flood plains? ________

---------- Is the course meandering? ---------------- Does the stream flow on bed rock anywhere? ---------------- Are there any lakes in this valley? ---------------------- ------------------------ Are there falls or rapids? ---------------------------------------- ---------- What evidence, if any, is there that the stream is enlarging its valley either laterally or vertically? --------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

What evidence, if any, is there that the stream is aggrading its valley? ----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

What does the condition of the stream and its relation to the valley indicate as to the age stage of the valley? --------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Processes of valley formation.**

In what part of its valley does a young stream cut most rapidly? ------------------ ------------------------------------------------------------------------------------------------------------------------------------------------------ What would be the valley form if this were the only process in valley formation? -------------------------

---------------------------------------------------------------- How does weathering aid in valley widening? ----------------------------------------------------------------

----------------------------------------------------------------

----------------------------------------------------------------

How does the stream itself tend to widen its valley? ----------------------------------------------------------------

----------------------------------------------------------------

----------------------------------------------------------------

---------------------------------------------------------------- Which is the more rapid, the vertical cutting by the stream, or weathering? ----------------------------------------------------------------
Which, therefore, represents the longer time for its formation, a broad valley or a gorge valley?

---------------------------------------------------------------- Apply these conclusions in proving your previous statement about the age stage of this valley. ----------------------------------------------------------------

----------------------------------------------------------------

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**Rate of valley formation.**

Have you ever observed, or heard of any change in the form of this valley? ----------------------------------------------------------------

Are visible changes to be expected in a year? ---------------- In ten years? ----------------

In a thousand years? ---------------- Is the rate of valley formation rapid or slow?

---------------- About how much material has been removed from the valley where you stand? Answer by filling out the following sentence: A depth of about ---------------- feet, and a width of about ---------------- feet (or miles). Where has all this material gone? ----------------------------------------------------------------

Is the stream always carrying sediment? ---------------- Write a brief paragraph stating what you conclude as to the rate of valley formation and the time required to form such a valley as this one. ----------------------------------------------------------------

**The future of the valley.**

Will the stream continue to erode this valley deeper? ________________ Where is its base level? ________________

Can it erode below that? ________________ Will weathering continue? ________________ Will its rate increase or decrease? ________________

________________ Write a brief paragraph telling what you consider to be the future of this valley, if no accident intervenes, giving reasons for your conclusions. ________________

## LV.—EXCURSION TO STUDY THE GENERAL PHYSIOGRAPHY OF THE REGION

**Materials.** **For Each Student. — The topographic map of the region, if published.**

**Purpose.** *To gain an appreciation of the physiographic features of the home region; its topography, drainage, and cultural relations.*

**Introductory.** If possible, these observations should be made from some elevated view point, such as the top of a hill overlooking the surrounding region, or a tower which affords a broad outlook. Failing such a vantage point, it may still be possible to find a site from which the general topography of the region can be appreciated and studied.

**Topography.** What great class or classes of rocks have you observed in this region? ................

................................................................................................................

................................................................................................ If sedimentary,

are the layers horizontal or inclined? ......................................................................

................................................................................................................

...................................... What can you infer from this as to the former condition of the region? ........................................................................................

................................................................................................................

................................................................................................................

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...................... What marked changes have occurred in the region since the time of the formation of the rocks? ........................................................................

................................................................................................................

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................................................................................................................

................................................................................................................

.............................. What is the topographic form of the region, *i.e.* is it a plateau, flood plain, mountain valley, etc.? ..................................................

---------------------------------------- What is the elevation above sea level of the place on which you are standing, as shown by your topographic sheet? ------------------

-------------------------- Locate and give the names and elevations of any other hills or summits which are visible and are shown on your map. ------------------------------------

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----------------------------------------------------------------------------------------

---------------------------------------------------- What can you say regarding their origin and history? ---------------------------------------------------------------

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----------------------------------------------------------------------------------------

**Drainage.** Locate and name the largest stream of the region. ------------------------------------

----------------------------------------------------------------------------------------

---------------------------------------------------- Is it a continuous or an intermittent stream? ------------------------------------------ What is the source of its water supply? ----------------------------------------------------------------------

----------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------

--------- To what drainage system does it belong? ------------------------------------

What tributaries has the main stream of this region?

Has the main stream a straight or meandering course?

Is it cutting down or building up its channel?

How do you explain this condition?

What is the topographic age of the stream valleys, — young, mature, or old?

Describe their form to show what you mean by applying such a term to them.

Are there any lakes, and if so, what caused them?

**Human occupation.**

What was the main physiographic factor which led to the establishment and growth of the community in which you live? What is the bearing of the fact that the main stream is navigable or not navigable? That the region is level, hilly, or mountainous? What has been the influence of the topographic age of the valleys on the growth and development of the region? What are the main lines of transportation and travel? In what ways have these been influenced or determined by the topography?

Is the climate of the region humid, dry, or arid? What has been the effect of the climatic conditions on the human occupation of the region?

Is the region an agricultural, grazing, mining, or manufacturing district? What physiographic factors have determined this?

Write a short paragraph stating the influence of the physiography on the settlement, present occupation, and development of the region in which you live.

# THE OCEAN

## LVI. OCEAN CURRENTS

**Purpose.** *To study the cause of the system of ocean currents, and to note the influence of the currents on temperature.*

**Relation of ocean currents to winds.** Figure 22 is a chart showing the system of ocean currents in the oceans of the world; and Figure 40 (p. 329) shows the prevailing winds over the oceans. In each case the arrows point in the direction of motion of the water or air. Compare these two charts to see how they resemble each other. For instance, how does the ocean current south of Australia, South America, and Africa compare with the wind direction in that region?

---

How do the winds and currents agree in the northern Atlantic and Pacific? ______________

---

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---

---

Why is the current in the southern hemisphere more regular than that in the northern?

---

---

What is the direction of winds in the tropical zone on each side of the equator?

---

---

How does the motion of the ocean waters correspond to this? ______________

---

What effect have the continents on the ocean currents? ______________

---

If you were to blow on the surface of a pan of water, which way would the water move?

---

What must be the effect of the steady blowing of the wind in one direction over a large body of water like the ocean? ______________________________________________

______________________________________________

From your study of the wind and ocean current charts, state the primary cause of the ocean currents. ______________________________________________

______________________________________________

______________________________________________

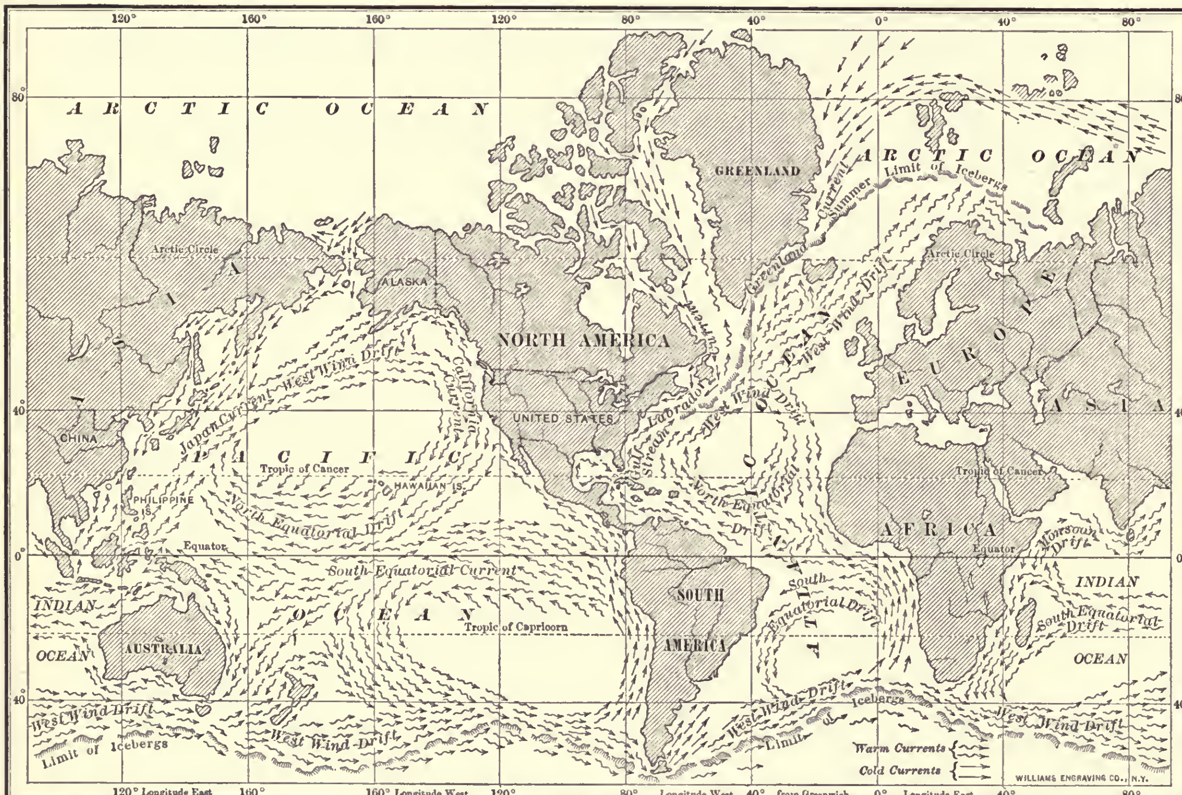


Fig. 22. — A Chart showing the Principal Ocean Currents and Ocean Drifts in the World.

**The ocean eddies.** On the chart (Fig. 22) locate two great eddies in the Atlantic Ocean and two in the Pacific. On which side of the equator does each lie? ______________________________________________

______________________________________________

______________________________________________

______________________________________________

Selecting one in the northern hemisphere, describe the motion of water in it, *e.g.* "it flows southwest, then west, then" ____________________

____________________

____________________

____________________

____________________ In other words, the direction of the current is constantly turning. Going with the current, which way is it turning, toward the right or toward the left?

____________________

The effect of the earth's rotation tends to turn, or deflect, all moving bodies toward the right in the northern hemisphere. Study the eddies in the southern hemisphere, and state in which way the currents are deflected in that hemisphere. ____________________

**Warm and cold currents.**

In the northern hemisphere, is a current from the south warm or cold, as compared to the ocean water on either side of it? ____________________

____________________ How about a current from the north? __________

Is the Labrador current cold or warm? ____________________

The Gulf Stream? ____________________ The west wind drift?

____________________ Which side of the North Atlantic has the warmer water, the American or the European? ____________________

Locate cool currents in the southern hemisphere and state their position and cause.

____________________

____________________

____________________

____________________

____________________

What effect on the temperature of the tropical oceans must the movement of ocean currents have? ____________________

What effect on the temperature of the Arctic regions must the movement of the ocean currents have? ____________________

Currents from which ocean, the Atlantic or Pacific, have the greatest effect on the Arctic?

____________________ Trace the southern limit of icebergs in the North Atlantic. On which side does the ice float farthest south? ____________________

Explain this. ____________________

____________________

____________________

____________________

____________________

Of what importance is the fact that icebergs come down across the path followed by the transatlantic steamers? ____________________

____________________

____________________

Fogs are caused by damp winds blowing from warm to cool regions. Knowing this, and by the aid of the ocean current chart, explain why the ocean near Newfoundland is one of the foggiest places on the earth. ____________________

____________________

**Effect of ocean currents on the temperature of the land.**

Why cannot the ocean currents themselves affect the temperature of the land?

____________________

What must help to carry their influence to the land? ____________________

What is the prevailing wind direction in the British Isles? ____________________
State why the climate of the British Isles is much warmer than that of southern Labrador, which lies in the same latitude. ____________________

____________________

____________________

____________________

____________________

Are east winds on the coast of New England warmed or cooled in passing over the adjacent ocean current? ____________________ How about winds from the south in the New England region? ____________________ State as fully as you can how the ocean currents influence the climate (*a*) of northern Europe;

(b) northeastern United States;

and (c) northwestern United States and Alaska.

On the blank chart (Fig. 23) sketch from memory the great eddies and the principal currents of the oceans, giving their names.


Fig. 23. — Chart for plotting Ocean Currents from Memory.

## LVII. — TIDES

**Purpose.** *To study the rise and fall of the tides at a given place in order to learn the time between tides, the variation in height of tides, and their relation to the moon's phases; also to learn the cause of tidal currents.*

| TIDES AT EASTPORT, ME., SEPTEMBER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | HIGH TIDES | | | | LOW TIDES | | | |
| | A.M. | | P.M. | | A.M. | | P.M. | |
| Date | Time | Height in Feet | Time | Height | Time | Height | Time | Height |
| | h. m. | | h. m. | | h. m. | | h. m. | |
| 1 | 2.01 | 18.6 | 2.25 | 18.7 | 8.10 | −0.2 | 8.41 | −0.5 |
| 2 | 2.54 | 17.8 | 3.14 | 18.0 | 9.01 | 0.7 | 9.38 | −0.1 |
| 3 | 3.50 | 17.0 | 4.15 | 17.4 | 10.00 | 1.5 | 10.40 | 0.7 |
| 4 | 4.52 | 16.3 | 5.19 | 17.0 | 11.03 | 2.0 | 11.46 | 0.9 |
| 5 | 6.00 | 16.0 | 6.26 | 17.1 | | | 12.11 | 2.1 |
| 6 | 7.08 | 16.1 | 7.31 | 17.5 | 0.54 | 0.7 | 1.18 | 1.8 |
| 7 | 8.11 | 16.8 | 8.32 | 18.2 | 1.56 | 0.2 | 2.21 | 1.1 |
| 8 | 9.08 | 17.6 | 9.28 | 19.0 | 2.55 | −0.5 | 3.17 | 0.1 |
| 9 | 9.59 | 18.3 | 10.18 | 19.4 | 3.45 | −1.2 | 4.08 | −0.6 |
| 10 | 10.43 | 19.0 | 11.04 | 19.7 | 4.34 | −1.5 | 4.54 | −1.2 |
| 11 | 11.27 | 19.3 | 11.48 | 19.5 | 5.16 | −1.6 | 5.37 | −1.4 |
| 12 | | | 12.08 | 19.2 | 5.58 | −1.4 | 6.20 | −1.3 |
| 13 | 0.30 | 19.0 | 12.49 | 18.9 | 6.38 | −0.8 | 7.02 | −0.8 |
| 14 | 1.12 | 18.3 | 1.30 | 18.2 | 7.18 | 0.0 | 7.43 | −0.1 |
| 15 | 1.54 | 17.4 | 2.12 | 17.4 | 8.00 | 1.0 | 8.28 | 0.7 |
| 16 | 2.38 | 16.4 | 2.56 | 16.6 | 8.42 | 2.0 | 9.15 | 1.5 |
| 17 | 3.25 | 15.5 | 3.43 | 15.9 | 9.30 | 2.9 | 10.07 | 2.2 |
| 18 | 4.16 | 14.8 | 4.37 | 15.3 | 10.23 | 3.6 | 11.02 | 2.5 |
| 19 | 5.12 | 14.4 | 5.34 | 15.1 | 11.21 | 3.9 | 11.58 | 2.6 |
| 20 | 6.10 | 14.4 | 6.31 | 15.4 | | | 12.20 | 3.7 |
| 21 | 7.08 | 15.0 | 7.26 | 16.0 | 0.55 | 2.2 | 1.16 | 3.1 |
| 22 | 8.00 | 15.9 | 8.18 | 16.9 | 1.48 | 1.5 | 2.11 | 2.1 |
| 23 | 8.48 | 16.9 | 9.07 | 17.9 | 2.38 | 0.7 | 2.58 | 1.0 |
| 24 | 9.32 | 17.9 | 9.53 | 18.8 | 3.22 | −0.2 | 3.44 | −0.1 |
| 25 | 10.16 | 18.9 | 10.38 | 19.4 | 4.08 | −1.0 | 4.27 | −1.1 |
| 26 | 10.59 | 19.6 | 11.22 | 19.7 | 4.49 | −1.5 | 5 11 | −1.8 |
| 27 | 11 42 | 20.0 | | | 5.31 | −1.7 | 5.55 | −2.1 |
| 28 | 0.08 | 19.8 | 12.26 | 20.0 | 6.15 | −1.5 | 6.41 | −2.1 |
| 29 | 0.54 | 19.6 | 1.13 | 19.7 | 7.00 | −1.0 | 7.30 | −1.7 |
| 30 | 1.42 | 18.9 | 2.04 | 19.1 | 7.48 | −0.3 | 8.23 | −1.1 |

**Explanation of diagram.** Figure 24 is a diagram showing the rise and fall of the tides at Eastport, Me., for the first 15 days of September during a certain year. At the top of the diagram, the figures 12, 6, 12, 6, 12, etc., represent hours of the day, the first 12 being midnight, the second 12 noon, the third 12 midnight again, etc. The first 6 is 6 o'clock in the morning; the second 6 is 6 P.M. Each of the vertical lines of the cross-section paper represents two hours of time. On the right and left margins the figures 0, 5, 10, 15, 20, etc., represent feet; and each horizontal line of the cross-section paper stands for 1 foot. The zigzag line represents the rise and fall of the tide for the first 15 days of the month. Study this diagram until you understand it. Notice, for example, in the tide table for this month, printed below, that the first high tide of Sept. 1 came at 2.01 A.M., and reached a height of 18.6 feet; the second high tide came at 2.25 P.M., and reached a height of 18.7 feet; the first low tide came at 8.10 A.M. and its elevation was — 0.2 foot; the second low tide, at 8.41 P.M., stood at — 0.5 foot. In making the diagram, four dots were placed in the proper positions under Sept. 1, two for the high tides and two for the low. These were then connected by the lines. The same procedure was followed for each of the other days.

**Completion of the diagram.** In the table on page 467 are data for the completion of the diagram (Fig. 24). Place dots in the proper positions for the last fifteen days of September, and then connect them with lines. You then have a diagram showing the rise and fall of the tides at one place for a month.

**Time between tides.** How many high (*flood*) and low (*ebb*) tides are there each day? ____________
From the table, determine the exact length of time between flood and ebb tide on a certain day. ____________ Between ebb and flood tide. ____________

____________ Between two successive flood tides. ____________

____________ Between two successive ebb tides. ____________

____________ Between the flood tides of successive days. ____________

____________ If the flood tide were to reach its greatest height at 12 o'clock, noon, on Sept. 10, at what time (approximately) would it reach its greatest height on Sept. 11?

____________ On Sept. 15? ____________

**Height of the tide.** What is the range (in feet) between the high and low tide on Sept. 1? ____________

____________ Find a day in which the range is greater than this. ____________

____________

____________ Find one in which the range is less. ____________

____________ How many periods of high range of tide are there in this month? ____________

____________ How many of low range of tide? ____________

____________ Between what days of the month is the tidal range high?

____________

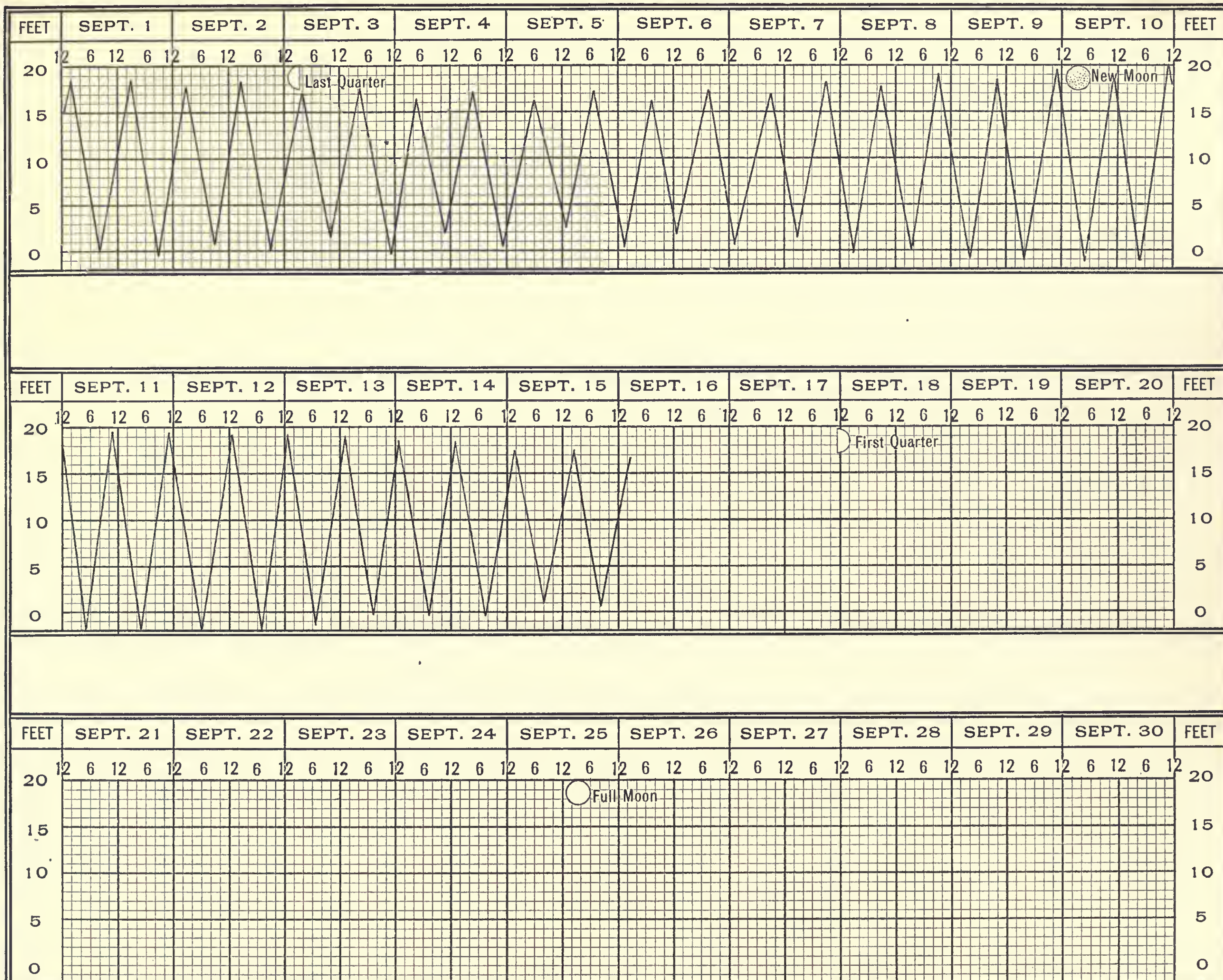


FIG. 24. — DIAGRAM SHOWING RISE AND FALL OF TIDES AT EASTPORT, ME., IN SEPTEMBER FOR A CERTAIN YEAR.

Between what days is it low? ________________

________________ Which two of these periods correspond with new and full moon? ________________

________________

________________ Which two with the first and last quarters of the moon? ________________

________________

________________ Which of these are the *spring* tides (see Text-book, p. 189)? ________________

________________ Which are the *neap* tides? ________________

________________ Are the sun and moon more nearly in line at new and full moon, or at the quarters? ________________

________________ What does the relation between moon and tidal range suggest as to the cause of tides? ________________

________________

________________

________________

**Tidal currents.** The tide causes a gradual rise and fall in the level of the ocean. It is essentially a vertical movement; but under some conditions the tide causes horizontal movements, which are called *tidal currents.* (Text-book, pp. 187–189.) In the diagram (Fig. 25) the tide rises 4.6 feet on one side of the island, and 4 feet on the other side. What will be the movement of water through the strait (*s*) at high tide? ________________

________________

________________

________________ If the tide rose to a height of 4 feet on both sides of the island, but high tide came a half hour later on one side than on the other, what would be the result in the strait (*s*)? ________________

________________

________________

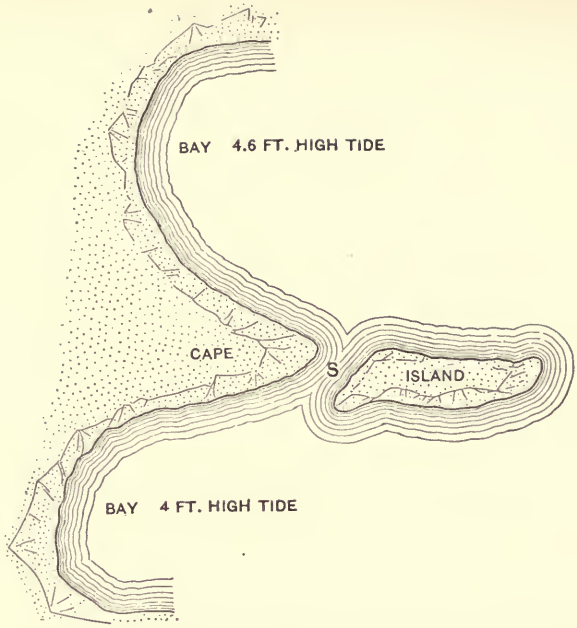


Fig. 25. — To show Differences in Height of Tide at Different Points.

How would such tidal currents affect the movements of ships? ____________________

________________________________________________________________________________

________________________________________________________________________________

____________________________________________________________ The transportation of sand and other sediment? ____________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

__________________________ When the currents move swiftly, they can carry much sediment. What must happen when the current is checked? ______________________________

________________________________________________________________________________

## THE ATMOSPHERE

### LVIII. — THE ATMOSPHERE HAS SUBSTANCE AND WEIGHT

**Materials.** **For Each Student.— A drinking glass. A piece of candle.**

**For General Class Use.— Air pump. A glass cylinder open at both ends. A glass tube 35 inches long sealed at one end. A bottle of mercury. A glass funnel. A ruler.**

**Purpose.** *To show that the atmosphere has substance and weight; also the principle of the barometer.*

**The air has substance.** What resemblance is there between a balloon floating in the air and a boat floating on the water? ________________________________________

________________________________________

________________________________________

Why does the balloon float? ________________________________________

________________________________________

________________________ What is the difference between water and air to sight?

________________________________________

Could a bird fly if the air were not a real substance? ____________ Could a sailboat move along? ____________ Would a windmill be turned? ____________

Give other proofs that the air is something real. ________________________

________________________________________

________________________________________

________________________________________

**The air is a mixture of gases.** What takes place when a match burns? ________________________

________________________________________

________________________________________

Would it burn more or less rapidly if the air were *all* oxygen? ____________

All carbon dioxide? ____________ Light a small piece of candle, and over it set an upturned glass. Note what happens. ________________________

________________________________________

Explain why the candle light went out.

Why is a lamp chimney made with an opening at both the top and bottom?

Make a list of the other substances of which the air is composed. (Text-book, p. 229.)

**The air has weight.**

Why must all substances on the earth have weight?

Why, then, must the atmosphere also have weight?

Place a glass cylinder, open at both ends, on the air pump. Press the palm of your hand on the upper end of the cylinder. Pump out the air from beneath your hand. What is the effect of the air above your hand?

Why do you not ordinarily feel the weight of the air?

**How much the air weighs.**

Two members of the class perform this experiment, the others watching closely and answering the questions below. One of the experimenters stands the glass tube on its closed end. What fills the tube? The other experimenter carefully fills the tube with mercury, using the glass funnel. What now fills the glass tube?

Into a drinking glass pour mercury enough to fill it to a depth of two inches. The student holding the glass tube now puts his thumb firmly over the open end of the tube, turns the tube upside down, thrusts the end beneath the mercury in the glass, and then removes his thumb. What happens? ______________________________

______________________________

The other experimenter next measures the height of the mercury in the tube, measuring from the surface of the mercury in the glass. How many inches long is the column of mercury?

__________ What is above it? __________ Why does the mercury not drop out of the tube? ______________________________

______________________________

______________________________

______________________________

______________________________

The result would have been the same if the tube had been a foot square, or an inch square, or any size. Fill out the following sentence. The weight of a column of air is equal to the weight of a similar column of mercury __________ inches high. A column of mercury 1 inch square at the base and 1 inch high weighs approximately $\frac{1}{2}$ pound. How much would a column of mercury 1 inch square and 30 inches high weigh? __________

How much, then, is the weight of a column of air 1 inch square? __________

Fill out the following sentence. The pressure of the atmosphere is equal to __________ pounds on every square inch.

**The barometer.** The apparatus just used is a rough form of barometer. Could water or other liquids be used in a barometer? __________ If water were used, would the column in the tube be higher or lower than the mercury column? __________ Why? __________

______________________________

______________________________

Why is mercury the best adapted liquid for use in barometers? __________

______________________________

For what purpose is the barometer used?

If there is a mercurial barometer in the school, examine it carefully and make a drawing of it, naming the important parts. Watch the barometer for the next few days to see if the column of mercury remains always at exactly the same height. Keep a record of your observations.

What do they show about the weight, or *pressure*, of the air?

## LIX. — THE THERMOMETER, AND THE DAILY RANGE OF TEMPERATURE

**Materials.** **For Each Student. — Ruler. Sharp pencil.**
**For General Class Use. — One or more thermometers.**

**Purpose.** *To understand the thermometer; to interpret the daily range of temperature; and to study the effect of inclination of the sun's rays.*

**The thermometer.** Examine the thermometer. What is in the space above the mercury? ________________

____________________________ If air were there, would the mercury rise and fall so easily?

______________ Why does not the mercury rise 30 inches, as in the barometer? ____________

________________________________________________________________________________________

________________________________________________________________________________ Does the mercury in the thermometer rise or fall when warmed? ______________________ Why?

________________________________________________________________________________________

________________________________________________________________________________________

State and explain the movement of the mercury when cooled. ____________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________ Could other liquids besides mercury be used for thermometers? ____________________________________________________

Fill out the following sentence: Liquids expand when warmed and ______________________ when cooled. Find out if the same is true of gases and solids. ____________________________

________________________________________________________________________________________

**Fahrenheit and Centigrade scales.** If your thermometer is graduated according to the Fahrenheit scale, what is its boiling point? ______________________ Its freezing point? ______________________ How many degrees are there between the boiling and freezing points? ______________________ By the Centigrade scale, freezing point is called 0° and boiling point 100°. How many degrees of Centigrade are equal to 1° of Fahrenheit? ______________________
Explain why it is true that to change Centigrade to Fahrenheit scale you multiply by 1.8 and add 32.

________________________________________________________________________________________

______________________________________________________________

Change 10° Centigrade into Fahrenheit degrees. ______________________________

______________________________ Change 25° Centigrade into Fahrenheit.

______________________________________________________________

**Making a curve to show daily range of temperature.**

Below is printed a record of the temperature for every two hours on a winter's day (Feb. 19), in a city in northern United States. In the diagram (Fig. 26) each of the horizontal lines represent 1°, and each of the vertical lines 2 hours. Make a cross to indicate the degree of temperature for each two hours (as shown in Fig. 26). Then connect the centers of these crosses with a line.

Temperature record for one day.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A. M. | Midnight<br>21° | 2<br>20° | 4<br>19° | 6<br>18.9° | 8<br>18.8° | 10<br>20.8° | Noon<br>23° |
| P. M. | 2<br>25° | 4<br>25.5° | 6<br>24° | 8<br>23.2° | 10<br>22° | Midnight<br>20° | |

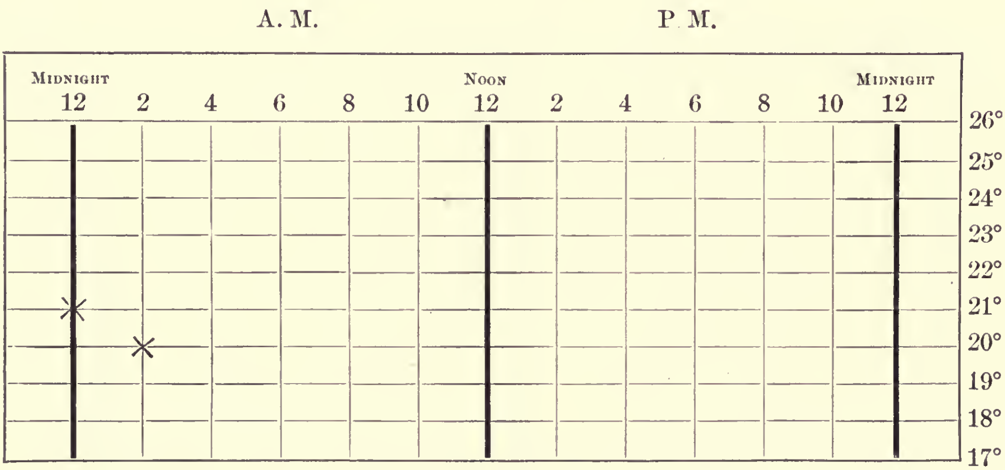


Fig. 26.

If possible make a similar curve (on the accompanying sheet of cross-section paper) representing local conditions. Data can be secured from the nearest Weather Bureau office, or from a self-registering thermometer. Failing such records, the pupils themselves may supply data, one pupil being sent to observe the temperature every two hours, during school hours, and volunteers bringing data from home for the evening and early morning.

**Study of the daily curve.**

At about what hour of the day was the temperature lowest? ______________________

______________ Highest? ______________________________ Why does the warmest period come after midday? ______________________________

______________________________________________________________

______________________________________________________________

The coldest after midnight? ______________________________

______________________________

**Making a daily curve for summer.** On the cross-section paper make a curve similar to that previously made, to show the range of temperature for a summer day. Following are data for such a curve, representing the temperatures for July 10 in a northern city.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A. M. | Midnight | 2 | 4 | 6 | 8 | 10 | Noon |
| | 60° | 56° | 55.4° | 57° | 65° | 74° | 80° |
| P. M. | 2 | 4 | 6 | 8 | 10 | Midnight | |
| | 85° | 83° | 79° | 73° | 66° | 61° | |

**Comparison of the two daily curves.** Why is it warmer at midday in summer (as shown in the diagram just drawn) than at midday in winter (as shown in the diagram for the winter day)? ______________________________

______________________________

______________________________

Why warmer during the night? ______________________________

______________________________

______________________________

In which of the diagrams is there greatest range between lowest and highest temperatures? ______________________________ Why is this true? ______________________________

______________________________

______________________________

______________________________

How do the two curves resemble each other? ______________________________

______________________________

______________________________

**Variation in amount of heat from the sun.** Fill out the following sentence: In both summer and winter the temperature is ______________ at midday than late in the afternoon; and the temperature is ______________ in summer than in winter. What relation do these facts have to the altitude of the sun?

______________________________

______________________________

To understand the reason why the altitude of the sun influences the temperature, draw two diagrams, as follows:

DIAGRAM 1. On the cross-section paper, mark heavily two of the vertical parallel lines an inch apart down to a certain horizontal line. How many spaces do these vertical parallel lines include at the horizontal line? ______________________ Starting from the same horizontal line, draw parallel lines (an inch apart), each at an angle of 45° with the horizontal line. How many spaces are included between *these* two parallel lines at the horizontal line? __________ __________ If these parallel lines in both cases represent rays of the sun, and the horizontal line the surface of the earth, in which case would a given area receive most rays? __________

________________________________________________________________________________

How does this help to explain the fact that the sun warms the earth more at midday than in the afternoon? ________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

In summer more than in winter? ________________________________________________

________________________________________________________________________________

________________________________________________________________________________

DIAGRAM 2. In the diagram (Fig. 27) draw two lines, one vertical, the other at an angle of 45°, both passing through the atmosphere to the same point on the surface of the earth

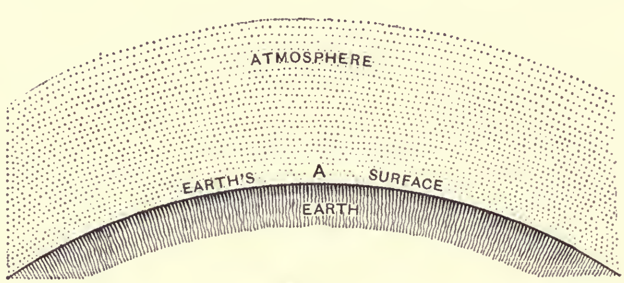


FIG. 27.

(marked *A*). Let each line represent a ray of sunlight. Measure with the ruler to see in which case the ray passes through a greater thickness of air. Which ray, then, would be most interfered with in its passage through the air? ______________________________________
How does this help to explain (*a*) the fact that the sun is warmer at noon than in the afternoon? ________________________________________________________________________

(*b*) that it is warmer in summer than in winter? ..........................................

.......................................................... (*c*) that you can often look directly at the sun just before sunset? ..........................................

.............................. Now state, clearly and concisely, why the sun's rays are warmer in summer than in winter, and at noon than in the afternoon. ..........................................

..........................................

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## LX.—WEATHER OBSERVATIONS

**Materials.** **For General Class Use.—One or more thermometers. A barometer. If possible, other meteorological instruments.**

**Purpose.** *To study local weather conditions.*

**Value of such a study.** Work of this nature will teach the use of the instruments; it will direct the student's attention to the weather phenomena that are always surrounding him; it will supply original data for later use, especially in the study of weather maps. For a part or all of the time that the class is studying the atmosphere a weather record may profitably be kept, using such instruments as the school possesses.

**How to keep the record.** For at least one week, at the same hour if possible, let each student make observations of the weather conditions and fill in the blank spaces in the table. After that, let a different student, each day, make the observations and report them to the class for entry in their tables.

| Date | Day of Week | Hour of Day | Temperature | Barometric Pressure | Wind Direction | Wind Velocity | Kinds of Clouds | Rain or Snow | Amount of Precipitation |
|---|---|---|---|---|---|---|---|---|---|
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |

| Date | Day of Week | Hour of Day | Tem-pera-ture | Baro-metric Pressure | Wind Direction | Wind Velocity | Kinds of Clouds | Rain or Snow | Amount of Precipita-tion |
|---|---|---|---|---|---|---|---|---|---|
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |

| Date | Day of Week | Hour of Day | Temperature | Barometric Pressure | Wind Direction | Wind Velocity | Kinds of Clouds | Rain or Snow | Amount of Precipitation |
|---|---|---|---|---|---|---|---|---|---|
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |
| | Mon. | | | | | | | | |
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| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
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| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
| | Thur. | | | | | | | | |
| | Fri. | | | | | | | | |

| Date | Day of Week | Hour of Day | Tem-pera-ture | Baro-metric Pressure | Wind Direction | Wind Velocity | Kinds of Clouds | Rain or Snow | Amount of Precipita-tion |
|---|---|---|---|---|---|---|---|---|---|
| | Mon. | | | | | | | | |
| | Tues. | | | | | | | | |
| | Wed. | | | | | | | | |
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| | Fri. | | | | | | | | |

## LXI. — THE SEASONAL TEMPERATURE RANGE

**Materials.** **For Each Student. — Colored pencils**

**Purpose.** *To study the monthly range of temperature in different regions; to see how it varies from place to place, and to interpret some of the variations. Also to study the daily range in some of these same places.*

**Making of a seasonal temperature curve.** Which is the hottest month in your locality? ______________________ The coldest month? ______________________ If you had twelve temperature records, one for every two hours in the day, how would you obtain the average or *mean temperature* for that day?

______________________________________________________________________

Knowing the mean temperature for each day in the month, how would you find the mean temperature for the month? ______________________________________________________

______________________ There follows a list giving the mean temperature (in Fahrenheit degrees) for each month of the year at a certain place in northern United States. From this data construct a curve on the cross-section paper to show the seasonal change in temperature. Let each vertical line represent a month, and each horizontal line 10°.

| Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31° | 32° | 35° | 45° | 60° | 70° | 75° | 74° | 68° | 56° | 45° | 34° |

The teacher may obtain (from the nearest Weather Bureau Station) the monthly mean temperatures for a place near the school. From this data construct a seasonal curve for your locality over the diagram just made, using a different colored pencil.

How does the seasonal temperature curve resemble the daily temperature curve?

______________________________________________________________________

______________________________________________________________________

When is the warmest period? ______________________ The coldest period? ___________

__________ Why do these periods not coincide exactly with the longest and the shortest days?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Clearly state the reasons why summer is the warmest, and winter the coldest period. _______

**Seasonal temperature curves in other parts of the world.**

There follows a table giving the monthly mean temperatures (approximate) for a number of places in different parts of the world. On the cross-section paper make a diagram to show the seasonal temperature curve for each of these places (all on one diagram). Let each horizontal line stand for 5° and every second vertical line for a month. Make room for temperatures as high as 95° and as low as 45°. For each curve use a differently colored pencil, or different symbols (such as dots or dashes).

| Place | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New York City | 37° | 31° | 35° | 52° | 62° | 72° | 75° | 75° | 70° | 56° | 45° | 33° |
| Singapore | 80° | 81° | 82° | 82° | 83° | 83° | 83° | 82° | 82° | 81.5° | 81° | 80° |
| Arctic, Lat. 82°, Fort Conger | −37° | −43° | −23° | −11° | 17° | 32° | 37° | 35° | 15° | −10° | −26° | −30° |
| Key West, Fla. | 69° | 68° | 72° | 75° | 79° | 81° | 84° | 83° | 83° | 80° | 74° | 69° |
| Yuma, Ariz. | 55° | 62° | 64° | 68° | 73° | 83° | 92° | 90° | 83° | 74° | 61° | 57° |
| St. Vincent, Minn. | −5° | 2° | 15° | 35° | 50° | 62° | 66° | 65° | 52° | 40° | 22° | 5° |
| Central Australia | 94° | 92° | 89° | 85° | 75° | 70° | 65° | 60° | 65° | 70° | 78° | 87° |
| Central Atlantic at equator | 79° | 80° | 80.5° | 81° | 80.5° | 80° | 79° | 80° | 80.5° | 81° | 80.5° | 79° |

In what one respect are most of these curves alike?

Why?

Why does the curve for Central Australia differ so widely from the others?

Which curve is the flattest?

Why?

Which region has the coldest summers?

The coldest winters?

What does the difference between the curve at St. Vincent and Key West or Singapore suggest as to the influence of distance from the sea?

Where do you find the highest temperatures?

State what you observe from the study of the diagrams (*a*) as to the influence of latitude on the seasonal temperature curve;

(*b*) as to the influence of distance from the sea.

The temperature falls on the average of 1° for every 300 feet of altitude. On the diagram (just drawn), dot in a curve to show a theoretical seasonal curve at an elevation of 3000 feet above New York City.

**Daily changes in temperature in different regions.**

On the cross-section paper plot the data in the following table to show the daily changes in temperature at some of the places for which the seasonal curves have just been drawn. Use colored pencils; use dots to represent the winter days and continuous lines for summer days. Let every other vertical line represent 3 hours of the day, and each horizontal line 5° of temperature. Make room for temperatures as high as 95° and as low as — 30°.

| Place | Midnight | 3 A.M. | 6 A.M. | 9 A.M. | Noon | 3 P.M. | 6 P.M. | 9 P.M. | Midnight |
|---|---|---|---|---|---|---|---|---|---|
| New York City. Summer | 62° | 58° | 59° | 65° | 72° | 79° | 78° | 72° | 60° |
| New York City. Winter | 10° | 8° | 6° | 12° | 24° | 30° | 25° | 18° | 10° |
| Arctic. Winter | −10° | −12° | −14° | −15° | −17° | −19° | −22° | −24° | −26° |
| Key West, Fla. Summer | 80° | 77° | 80° | 84° | 89° | 90° | 87° | 82° | 79° |
| Key West, Fla. Winter | 69° | 65° | 69° | 73° | 78° | 79° | 75° | 71° | 69° |
| St. Vincent, Minn. Summer | 60° | 55° | 59° | 69° | 78° | 85° | 78° | 69° | 60° |
| St. Vincent, Minn. Winter | −22° | −27° | −29° | −19° | −12° | −11° | −13° | −20° | −23° |
| Central Atlantic at Equator. Summer | 79.8° | 79.5° | 79.3° | 80° | 80.5° | 81° | 80.5° | 80° | 79.8° |
| Central Atlantic at Equator. Winter | 79.9° | 79.6° | 79.3° | 80° | 80.5° | 81° | 80.6° | 80.1° | 79.9° |

In what respect are all but one of these daily curves alike? ____________________

____________________________________________________________

____________________________________________ Which one does not show the midday rise? ______________________________ Why does it not?

____________________________________________________________

____________________________________________________________

Which curve shows the greatest change between day and night? ____________________

______________ Explain. ____________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________ Which the least? ______________________________

Explain. ____________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

Where is it coldest? ______________________________ Where warmest?

---------------------------------------------- What evidence do you find of (*a*) influence of ocean? ---------------------------------------------------------------

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------

(*b*) of influence of distance from sea? ------------------------------------------------

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------

---------------------------------------- (*c*) of influence of latitude? -------------------------

---------------------------------------------------------------------------------------------------

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## LXII. — MOISTURE IN THE AIR

**Materials.** **For Each Student. — Two small pieces of cheese cloth, two or three inches square.**

**For General Class Use. — A fruit jar. (A small vial of alcohol or ether.) A small piece of muslin. Two thermometers.**

**Purpose.** *To understand the four different conditions which affect the rate of evaporation; the meaning of relative and absolute humidity; and the use of the table for determining the relative humidity, on the basis of observations of temperature with the dry and wet bulb thermometers.*

**Note.** NOTE: — To save time the teacher will probably direct that two or more of these experiments be carried on at the same time.

**Water vapor in the air.** After it has stopped raining the sidewalks soon become dry. What has become of the water? ____________________

What term is applied to the change from water to water vapor? ____________________

Is the water vapor a liquid or a gas? ____________________ Is it visible or invisible? ____________________ All over the earth water is evaporating, and the water vapor is rising into the air; but the rate at which evaporation takes place varies greatly under different conditions. The following experiments are intended to illustrate this fact.

**Experiments to illustrate variation in the rate of evaporation.** Wet both the pieces of cheese cloth. Put one on the radiator, or in the sun, or in some other warm place. Put the other on your desk, and not in the sun. Which piece of cloth becomes dry first? ____________________ From this experiment what do you conclude as to the rate of evaporation at different temperatures? ____________________

____________________

Would evaporation therefore be more rapid in the frigid zone or in the torrid zone? ____________________ In summer or in winter? ____________________

Again wet each piece of cloth, wringing out the surplus water. Pin one of the pieces on each end of your desk. With a book or piece of paper, fan one of the pieces of cloth. Which dries the more quickly? ____________________ What do you conclude from the results of this experiment as to the rate of evaporation where the wind is blowing, as compared to the rate where it is calm? ____________________

____________________ Would evaporation, therefore, be more rapid on a windy day or on a day when there is no wind? ______________________________________

Would it be more rapid in the trade wind belt, or in the belt of calms? __________________

Once more wetting the two pieces of cloth, spread one out on the desk and make a small

roll of the other. Which dries the more quickly? ________________________________________
What do you conclude from this experiment as to the relation between the amount of evapo-

ration and the amount of surface exposed? ______________________________________________

______________________________________________. Would there, therefore, be more water vapor rising from a large body of water (such as the ocean) or from a small body (such as a pond)?

________________________________________________ Which would probably have more vapor,

winds from the land or winds from the ocean? ____________________________________________

While these experiments were being carried on, the teacher has placed a small amount of water in the bottom of a fruit jar and, putting on the cover, has set it in a warm place. Evaporation has caused much water vapor to rise into the air in the jar, and this air is therefore very damp. Now suspend a piece of wet cloth (by a string) in the jar, and put back the cover. At the same time spread out another piece of wet cloth on the desk. When the cloth

on the desk is dry, take out the piece of cloth from the jar. Is it dry? ____________________
What do you conclude as to the rate of evaporation in dry air as compared to that in damp

air? ____________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

Would evaporation, therefore, be more rapid on a damp day or on a dry day? ______________

____________________ In a desert or in a humid region? ____________________________________

**Meaning of absolute and relative humidity.**

A quart dish half full of water has $\frac{1}{2}$, or 50%, as much water as it can hold. This percentage represents the *relative* amount of water in the glass compared with what the dish

*might* hold. What would be the percentage if the dish were full? __________________________

_____________________________ What if $\frac{3}{4}$ full? ___________________________________________
You could state the amount of water in the dish in two ways: that is, you could say, when the dish was half full, that the *absolute amount* was a pint; or, you could say that the amount relative to what the dish might hold was 50%.

It is important sometimes to speak of the absolute and relative amounts of vapor in the air. If you had a given quantity of perfectly dry air, and let one pint of water evaporate

into it, what would be the absolute amount of vapor in the air? ______________________________

____________________ This would be called its *absolute humidity.* To determine the *relative* *humidity* you would need first to know how much vapor could possibly pass into that quantity of air. Suppose the amount of water that this quantity of air could hold was 4 pints; what would be the relative humidity when its absolute humidity was 1 pint? ______________ ______________________________ What would be its relative humidity if there were 2 pints in it? ____________________________________________ What if there were 4 pints in it? ____________________________________________ Could it then take any more water vapor? ____________ What, then, is meant by *saturated* air? ________________________________________ ____________________________________________ Was the air saturated when the water was being evaporated from the pieces of cloth on the desk? ______________ If it had been, could there have been any evaporation? ______________

**Determining relative humidity.** Evaporation is a cooling process, because in evaporation heat must be used. This can be proved by placing a drop of ether or alcohol on the back of the hand. As it evaporates it takes some heat from the hand and therefore feels cool. Take two thermometers and hang them side by side. Tie (with thread) a small piece of muslin around the bulb of one, with one end of the muslin hanging down like a wick. Read the two thermometers. Now saturate the muslin with alcohol and watch the mercury of this thermometer. Why does this thermometer register a lower temperature than the other? ______________________________ ____________________________________________________________________________ ____________________________________________________________________________ ________________________________________________________________ See if water has the same effect as alcohol, saturating the muslin and letting the wick end rest in a glass of water; but, since water does not evaporate as fast as alcohol, fan the muslin to make the water evaporate more rapidly.

It is possible to determine the relative humidity of the air by using two such thermometers—a *dry bulb* and a *wet bulb* thermometer. The principle is that the evaporation lowers the temperature. The temperature is lowered more if evaporation is rapid than if slow. Which is dryest, air with low relative humidity, or air with high relative humidity? ____________________________________________ In which will evaporation be more rapid, air with high or low relative humidity? ________________________________________ From this do you conclude that the difference in temperature as shown by the dry and wet bulb thermometers would be greater when the relative humidity is high, or when low? ______________________________ ____________________________________________________________________________

Following is a table which can be used to determine the relative humidity. First find the difference in temperature of the dry and wet bulb thermometers. Suppose it to be 3°. Find the number 3 (the third figure from the left) at the top of the table. In the left-hand column of the table find the number that corresponds with the temperature recorded by the dry bulb thermometer, which we will assume to be 78°. Now follow this to the right until you come to the number in the column under the 3. That number is 87, and this is the relative humidity. That is, the relative humidity is 87%.

Below is a table showing observations made, and the relative humidity indicated by them, as deduced from the table.

| Date | Dry Bulb | Wet Bulb | Difference in Reading | Relative Humidity |
|---|---|---|---|---|
| Jan. 1 | 80° | 78° | 2° | 92% |
| Jan. 2 | 82° | 78° | 4° | 84% |
| Jan. 3 | 74° | 67° | 7° | 70% |

Verify these data by use of the table for determining relative humidity. Make observations with the dry and wet bulb thermometers, both in the schoolroom and out of doors, and, by reference to the table, find the relative humidity. Set down the results, below, in a table similar to that just given.

| Temperature of Dry Bulb Thermometer | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20° . . . | 85 | 70 | 56 | 41 | 27 | 13 | | | | | | | | | | | | | | | | | | | |
| 22° . . . | 86 | 72 | 58 | 45 | 32 | 19 | 6 | | | | | | | | | | | | | | | | | | |
| 24° . . . | 87 | 74 | 61 | 48 | 36 | 24 | 11 | | | | | | | | | | | | | | | | | | |
| 26° . . . | 88 | 75 | 63 | 51 | 40 | 28 | 17 | 6 | | | | | | | | | | | | | | | | | |
| 28° . . . | 88 | 77 | 65 | 54 | 43 | 33 | 22 | 11 | 1 | | | | | | | | | | | | | | | | |
| 30° . . . | 89 | 78 | 67 | 57 | 47 | 36 | 26 | 17 | 7 | | | | | | | | | | | | | | | | |
| 32° . . . | 90 | 79 | 69 | 59 | 50 | 40 | 31 | 21 | 12 | 3 | | | | | | | | | | | | | | | |
| 34° . . . | 91 | 81 | 72 | 62 | 53 | 44 | 35 | 26 | 17 | 9 | | | | | | | | | | | | | | | |
| 36° . . . | 91 | 82 | 73 | 66 | 56 | 47 | 38 | 30 | 22 | 14 | 6 | | | | | | | | | | | | | | |
| 38° . . . | 92 | 83 | 75 | 67 | 58 | 50 | 42 | 34 | 26 | 18 | 11 | 3 | | | | | | | | | | | | | |
| 40° . . . | 92 | 84 | 76 | 68 | 60 | 53 | 45 | 38 | 30 | 22 | 16 | 8 | 1 | | | | | | | | | | | | |
| 42° . . . | 92 | 84 | 77 | 69 | 62 | 55 | 48 | 40 | 34 | 27 | 20 | 13 | 6 | | | | | | | | | | | | |
| 44° . . . | 92 | 85 | 78 | 70 | 63 | 57 | 50 | 43 | 37 | 30 | 24 | 17 | 11 | 5 | | | | | | | | | | | |
| 46° . . . | 93 | 85 | 79 | 72 | 65 | 58 | 52 | 46 | 39 | 33 | 27 | 21 | 15 | 9 | 3 | | | | | | | | | | |
| 48° . . . | 93 | 86 | 79 | 73 | 66 | 60 | 53 | 48 | 42 | 36 | 30 | 24 | 19 | 13 | 7 | 2 | | | | | | | | | |
| 50° . . . | 93 | 87 | 80 | 74 | 67 | 61 | 55 | 50 | 44 | 38 | 33 | 27 | 22 | 16 | 11 | 6 | 1 | | | | | | | | |
| 52° . . . | 94 | 87 | 81 | 75 | 69 | 63 | 57 | 51 | 46 | 40 | 35 | 30 | 24 | 20 | 15 | 10 | 5 | | | | | | | | |
| 54° . . . | 94 | 88 | 82 | 76 | 70 | 64 | 59 | 53 | 48 | 43 | 38 | 32 | 28 | 23 | 18 | 13 | 8 | 4 | | | | | | | |
| 56° . . . | 94 | 88 | 82 | 77 | 71 | 65 | 60 | 55 | 50 | 44 | 40 | 35 | 30 | 25 | 21 | 16 | 12 | 8 | 3 | | | | | | |
| 58° . . . | 94 | 89 | 83 | 78 | 72 | 67 | 61 | 56 | 51 | 46 | 42 | 37 | 33 | 28 | 24 | 19 | 15 | 11 | 7 | 2 | | | | | |
| 60° . . . | 94 | 89 | 84 | 78 | 73 | 68 | 63 | 58 | 53 | 48 | 44 | 39 | 34 | 30 | 26 | 22 | 18 | 14 | 10 | 6 | 2 | | | | |
| 62° . . . | 95 | 89 | 84 | 79 | 74 | 69 | 64 | 59 | 54 | 50 | 45 | 41 | 37 | 32 | 28 | 24 | 20 | 16 | 13 | 9 | 5 | 1 | | | |
| 64° . . . | 95 | 90 | 85 | 79 | 74 | 70 | 65 | 60 | 56 | 51 | 47 | 43 | 38 | 34 | 30 | 27 | 23 | 19 | 15 | 12 | 8 | 5 | 1 | | |
| 66° . . . | 95 | 90 | 85 | 80 | 75 | 71 | 66 | 61 | 57 | 53 | 49 | 45 | 40 | 36 | 32 | 29 | 25 | 22 | 18 | 14 | 11 | 8 | 4 | 1 | |
| 68° . . . | 95 | 90 | 85 | 81 | 76 | 71 | 67 | 63 | 58 | 54 | 50 | 46 | 42 | 38 | 34 | 31 | 27 | 24 | 20 | 17 | 14 | 10 | 7 | 4 | 1 |
| 70° . . . | 95 | 90 | 86 | 81 | 77 | 72 | 68 | 64 | 60 | 55 | 52 | 48 | 44 | 40 | 36 | 33 | 29 | 26 | 23 | 19 | 16 | 13 | 10 | 7 | 4 |
| 72° . . . | 95 | 91 | 86 | 82 | 77 | 73 | 69 | 65 | 61 | 57 | 53 | 49 | 45 | 42 | 38 | 35 | 31 | 28 | 24 | 22 | 18 | 15 | 12 | 9 | 6 |
| 74° . . . | 95 | 91 | 86 | 82 | 78 | 74 | 70 | 66 | 62 | 58 | 54 | 50 | 47 | 43 | 40 | 36 | 33 | 30 | 26 | 23 | 20 | 18 | 15 | 12 | 9 |
| 76° . . . | 95 | 91 | 87 | 82 | 78 | 74 | 70 | 66 | 63 | 59 | 55 | 52 | 48 | 45 | 41 | 38 | 35 | 31 | 28 | 25 | 22 | 20 | 17 | 14 | 11 |
| 78° . . . | 96 | 91 | 87 | 83 | 79 | 75 | 71 | 67 | 63 | 60 | 56 | 53 | 49 | 46 | 43 | 39 | 36 | 33 | 30 | 27 | 24 | 21 | 19 | 16 | 13 |
| 80° . . . | 96 | 92 | 87 | 83 | 79 | 75 | 72 | 68 | 64 | 61 | 57 | 54 | 51 | 47 | 44 | 41 | 38 | 35 | 32 | 29 | 26 | 23 | 20 | 18 | 15 |
| 82° . . . | 96 | 92 | 88 | 84 | 80 | 76 | 72 | 69 | 65 | 62 | 58 | 55 | 52 | 48 | 45 | 42 | 39 | 36 | 33 | 31 | 28 | 25 | 22 | 20 | 17 |
| 84° . . . | 96 | 92 | 88 | 84 | 80 | 77 | 73 | 69 | 66 | 63 | 59 | 56 | 53 | 49 | 46 | 44 | 41 | 38 | 35 | 32 | 29 | 27 | 24 | 22 | 19 |
| 86° . . . | 96 | 92 | 88 | 84 | 81 | 77 | 73 | 70 | 67 | 63 | 60 | 57 | 54 | 51 | 48 | 45 | 42 | 39 | 36 | 34 | 31 | 29 | 26 | 23 | 21 |
| 88° . . . | 96 | 92 | 88 | 85 | 81 | 77 | 74 | 71 | 67 | 64 | 61 | 58 | 55 | 52 | 49 | 46 | 43 | 40 | 38 | 35 | 32 | 30 | 27 | 25 | 22 |
| 90° . . . | 96 | 92 | 88 | 85 | 81 | 78 | 75 | 71 | 68 | 65 | 62 | 59 | 56 | 53 | 50 | 47 | 44 | 41 | 39 | 36 | 34 | 32 | 29 | 26 | 24 |

## LXIII. — CONDENSATION OF WATER VAPOR

**Materials.** **For Each Student. — A drinking glass. Water. Either snow or small pieces of ice.**

**Purpose.** *To understand the causes leading to the condensation of water vapor, and the consequent formation of dew, frost, fog, clouds, rain, and snow.*

**Meaning of saturation and dew point.** In which can there be most vapor, warm air or cold air? ________________
If the relative humidity of the air is 90 % when the temperature is 70°, would the temperature need to be raised or lowered to bring the relative humidity to 100 %? ________________

________________ If the temperature continued to change in the same direction until after the point of saturation was reached, what would happen? ________________

________________ What reason can you give for calling the point of saturation (relative humidity 100 %) the *dew point?* ________________

________________

________________

**Formation of dew.** Breathe against a cold object, like a window pane. What happens? ________________

________________ Explain why the vapor was condensed? ________________

________________

________________

________________ Fill the drinking glass two thirds full of water and ice (or snow) and stir the mixture, being careful not to wet the outside of the glass. Explain why water begins to appear on the outside of the glass.

________________

________________

________________

In the evening, when the ground cools by radiation, dew often forms. Explain the cause of the formation of dew. ________________

________________

________________

Would dew form most quickly when the relative humidity is high, or low? When would no dew form?

What forms if the dew point is below the freezing point?

**Determination of dew point.** Again place water and snow (or ice) in the drinking glass and stir the mixture carefully with the thermometer. Note when vapor first begins to condense on the outside of the glass and then read the thermometer. The temperature of that reading is the dew point for the air in the room. Determine the dew point by this method.

**Formation of fog.** When you breathe into the air of a cold winter day, you can "see your breath." What is it that you see?

Explain what has happened.

What must happen when warm, damp winds blow over a cold surface?

On this basis, explain why it is that the cold Labrador current is such a foggy part of the ocean.

Why is it that winds often cause fog on mountains?

**Formation of clouds.** Air that rises above the earth's surface expands; and when air expands it grows cooler. What then must result if damp air (or air with high relative humidity) rises to a considerable height?

If you could see a fog from either above or below, it would look like a cloud.

Explain why clouds form every day in the warm, humid belt of calms. ____________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________ Explain why clouds appear on warm, humid summer days. ____________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

**Observation of clouds.**

In the Text-book (p. 248) you will find the names of the principal forms of clouds. What form have the clouds to-day? ______________________________ Keep a record of the clouds for a week, giving their name, form, and a brief description, in the following table. From which kind of cloud does rain or snow fall? ______________________________

| Day of Week | Name of Cloud | Description of Clouds |
|---|---|---|
| Monday | | |
| Tuesday | | |
| Wednesday | | |
| Thursday | | |
| Friday | | |

**Formation of rain.**

If condensation continues, will the clouds grow larger or smaller? ____________________ ____________________ What does the fact that the fog particles float in air currents indicate as to their size? ______________________________ When condensation continues, what must be the effect on the size of the particle? ____________________ ____________________ What must then happen? ______________________________ ______________________________ Under what conditions is snow formed instead of rain? ____________________________________________

**Causes for differences in rainfall.**

In the belt of calms the air is rising. Would this be a rainy or a dry region? __________ ______________________________ State your reasons for this conclusion. __________

In the horse latitude belt the air is descending. Would this be a rainy or a dry region? State your reasons for this conclusion.

Where winds blow from the ocean against rising land, would there be much or little rain? State your reasons for this conclusion.

Where winds blow from the land to the ocean, what condition of rainfall would there be? State your reasons for this conclusion.

## LXIV. — ISOTHERMAL CHARTS OF UNITED STATES

**Materials.** **For Each Student. — Colored pencils.**

**Purpose.** *To make and understand an isothermal chart; to study and interpret a summer and winter isothermal chart of the United States; and to bring out the fact that temperature conditions are of great and fundamental importance to vegetation.*

**Making an isothermal chart.** On the accompanying map (Fig. 28) are marked the temperatures at a number of localities in the United States at 8 A.M. on a winter's day. With this data draw in (as directed below) *isothermal lines* so as to connect places having the same temperature. Your map then becomes an *isothermal chart.* It will be sufficient to draw an isothermal line for every ten degrees; *e.g.* for 0°, 10°, 20°, etc.

In making the map start with the isothermal line for 50°. Since the temperature at New Orleans was 50°, it is evident that the line will have to pass through that city. Will it run

through Mobile? ______________ Macon? ______________ Augusta? ______________

Will it then continue nearer Raleigh (48°) or Wilmington, N.C. (56°)? ______________

______________ Draw the line at what you think is the proper distance from Raleigh. At Norfolk the temperature was 54°. Will the 50° isotherm pass on the cold side

(north) or on the warm side (south) of Norfolk? ______________
Continue the 50° isothermal line southeastward from New Orleans. On which side of Galves-

ton does it extend? ______________ On which side of Corpus

Christi, Tex.? ______________

Now draw the 60° and 70° isothermal lines across the Florida peninsula. Then draw in the other isotherms down to 20° below zero. Shade (with blue pencil) the part of the map with a temperature below 30°; this is (approximately) the area of the country where the temperature is below freezing point on that day. ______________

______________

**Questions on the isothermal chart.** Where is the coldest area? ______________

______________ Why should it be coldest there? ______________

______________

______________

______________

Why does the 30° isotherm extend farther south in the interior than on the east and west coasts? ...

Why should it be farther north on the west than on the east coast? ...

Fill out this sentence: This isothermal chart shows that in winter the temperature ... from south to north; and it also shows that the temperature ... from seacoast to interior.

**Study of isothermal charts of United States for January and July.**

The isothermal chart that you have just made represents the conditions in the country at 8 o'clock on a *single* day. If all the temperature records at each locality for a month were averaged together, an isothermal chart could be made for that month. This is what has been done in the two charts (Figs. 29 and 30), one for the month of January, the other for July.

With the colored pencils shade in the following areas: (*a*) those with temperatures below 0°; (*b*) those with temperatures between 0° and 30°; (*c*) those with temperatures between 30° and 50°; (*d*) those with temperatures between 50° and 70°; (*e*) those above 70°.

What is the general direction that the isotherms follow? ...

Where is there the greatest departure from this direction? ...

What is the explanation of this? ...

On which coast, the Atlantic or the Pacific, is there the greatest difference in temperature in going from north to south? ...

How much difference in temperature is there between the north and south ends of each coast in summer? ...

In winter? ...


FIG. 28. — MAP WITH TEMPERATURES AT 8 A.M., ON A WINTER'S DAY.

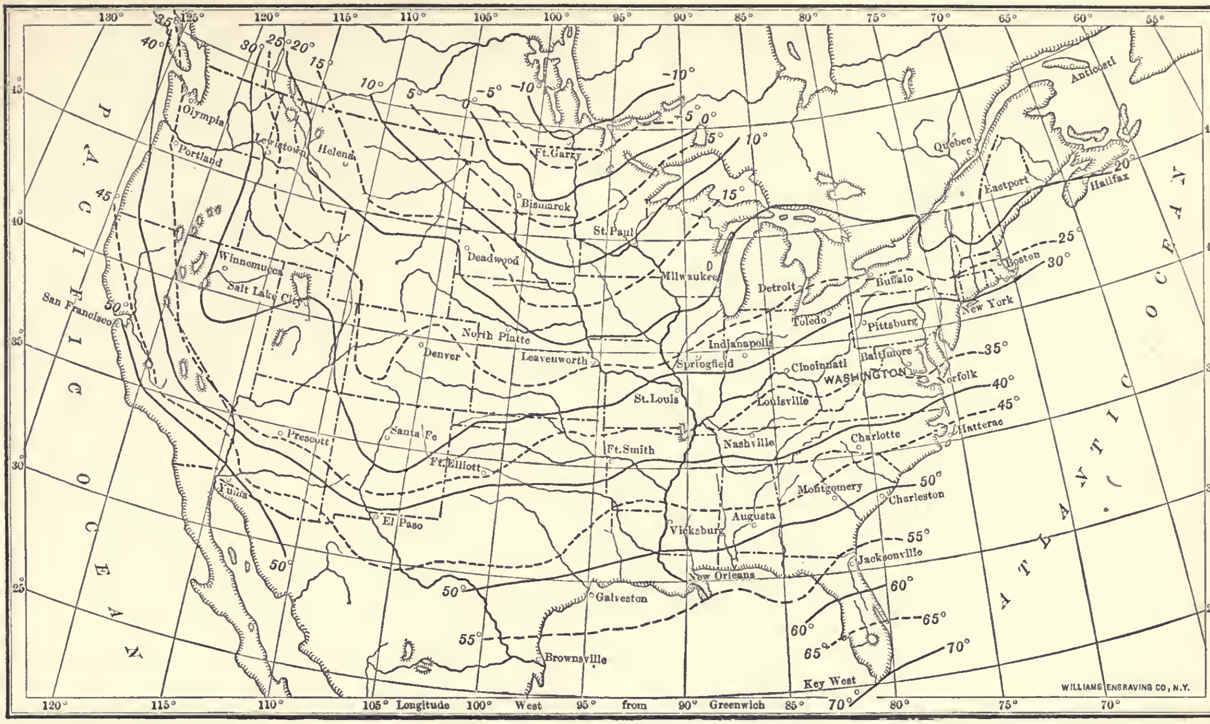


FIG. 29. — ISOTHERMAL CHART OF UNITED STATES FOR JANUARY.

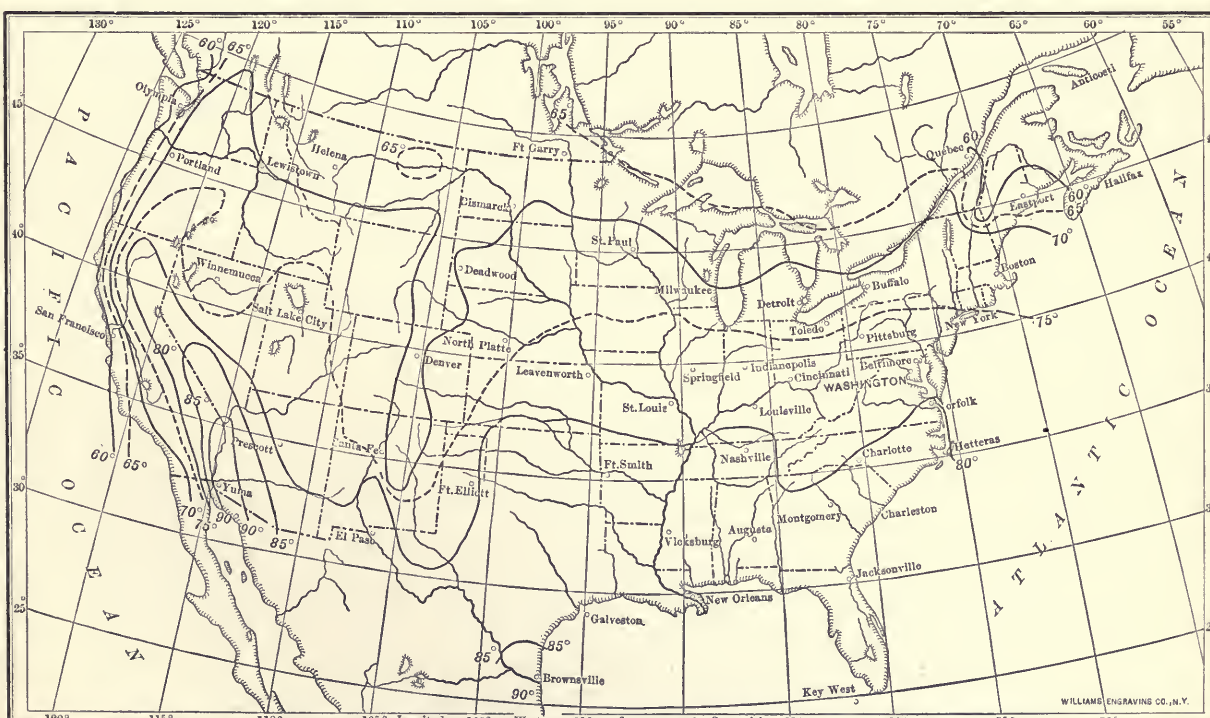


FIG. 30. — ISOTHERMAL CHART OF UNITED STATES FOR JULY.

Why is there a marked difference of temperature range on the two coasts?

Which of these two monthly charts does Figure 28 most resemble?

Do Figures 28, 29, and 30 show the same general features?

In what part of the country is there the greatest difference in temperature between summer and winter?

Why is this so?

Where is there the least difference?

Explain this also.

Which is the most southern point in the country?

Is it the warmest place in the country in summer? Account for this.

What is the warmest place in the country in winter?

Which is the most northern point in the country?

Is it also the coldest part of the country in winter? Explain.

## LXV. — THE RELATION OF WINDS TO ATMOSPHERIC PRESSURE

**Purpose.** *To show that winds are caused by the flowing of air from regions of high pressure to regions of lower pressure.*

**Movement of light and heavy air.** The air near a hot stove, a radiator, or lamp, is warmed. Hold a light, downy feather near one of these and then release it. What is the movement of the current of air near this heated object? ______________ Why is this so? ______________

______________

______________

______________ Could the air rise *against* gravity unless something were pushing it up? ______________ When the warm air near a stove is rising, what is the movement of the cooler, heavier air in other parts of the room? ______________

______________ What effect has this movement on the warm, lighter air? ______________

______________

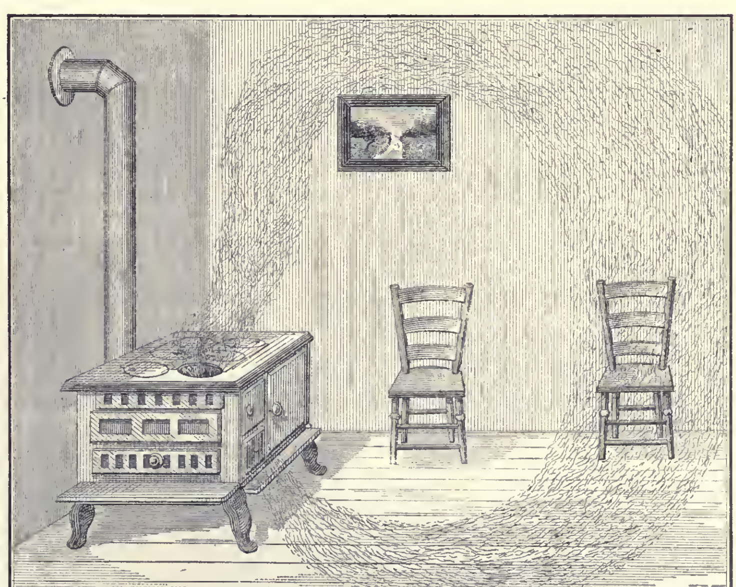

FIG. 31. — DIAGRAM FOR SHOWING CIRCULATION OF AIR IN ROOM HEATED BY A STOVE.

____________________ In the diagram (Fig. 31) draw arrows to show the circulation of the air in a room warmed by a stove. Fill in the following sentence, putting the words "lighter" or "heavier" in their proper places.

Warm air is ____________ than cool air; the cool ____________ air settles and forces up the ____________ warm air. This causes the cool ____________ air to flow toward places of warm ____________ air.

**Meaning of barometric pressure and of isobars.**

Is it true on the earth, as well as in a room, that heavy air will flow toward regions of light air and force the light air to rise? ____________ What is the instrument that is used to measure the weight or pressure of the air? ____________ Recalling your study of the barometer, which, heavy or light air, makes the mercury rise higher in the instrument? ____________ At about what height does the mercury stand in the barometer tube? ____________ Does a reading of the barometer of 29.8 inches mean heavier or lighter air than a reading of 30.2 inches? ____________ Which of these two would be called *high pressure?* ____________

Which *low pressure?* ____________

Figure 32 is a map of the United States showing the pressure of the air for a certain day in winter. The lines are called *isobars* (meaning equal weight), and each line passes through places having the same air pressure, or weight. The figures on each line show the pressure in inches of mercury in the barometer on this day. Find the place with the lowest pressure and write in the words "low pressure." Is this a region of light air or of heavy air? ____________ On the map mark in the words "high pressure" where they belong.

**Winds and pressure.**

From the center of which of these areas will the air flow outward? ____________ What would you call this flowing of the air? ____________ Toward the center of which of the areas will the wind blow? ____________ With arrows mark in the winds as you think they would go with such a condition of pressure as shown on this map.

Water running down a slope is often said to flow *down grade*. The winds shown on your map are not flowing down a slope, but the air is flowing from a region of high barometric pressure to one of low barometric pressure. What reason can you give for calling the difference in pressure between two places a *barometric gradient?* ____________

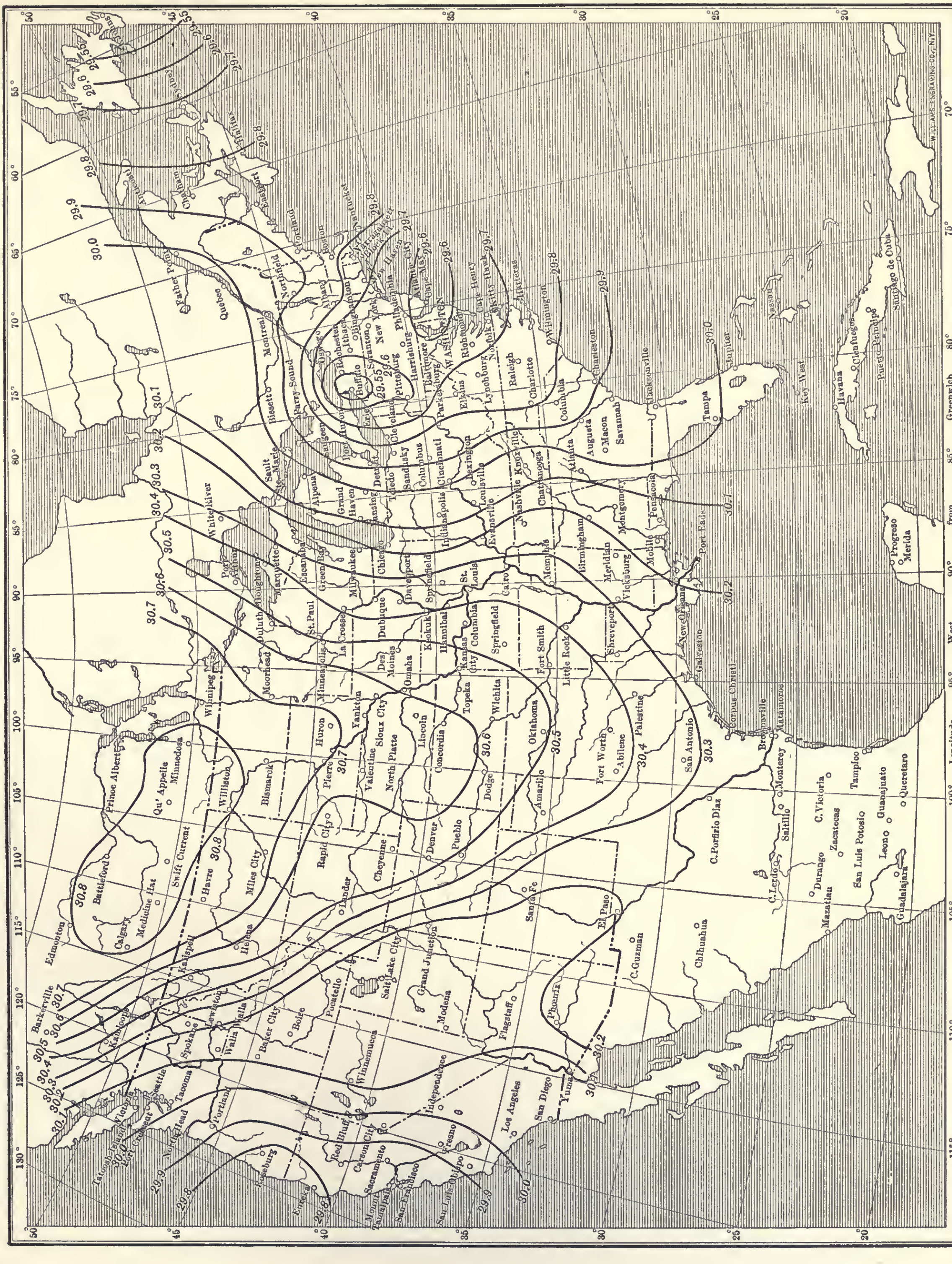


FIG. 32. — MAP TO SHOW PRESSURE OF AIR ON A CERTAIN DAY IN WINTER.

______________________________________________________________________

______________________________________________________________________

______________________________ Is the barometric gradient steepest where the isobars are close together or far apart? ______________________

Where is it gentlest? ______________________ On what kind of a grade does water flow most swiftly? ______________________ On what kind of a barometric gradient will air flow most swiftly? ______________________

______________ On your map mark places where the air must be moving swiftly. Would these regions have strong or light winds? ______________________

What would be the case where the barometric gradient is gentle? ______________________

On Figure 33 the arrows represent winds observed on a certain day in a part of the United States. On this map sketch in a number of isobars to show the location of the area of low pressure and the area of high pressure.


FIG. 33. — MAP TO SHOW WIND DIRECTIONS OBSERVED ON A CERTAIN DAY IN PART OF THE UNITED STATES.


*Scale of Statute Miles*

0 100 200 300 400 500

FIG. 34. — MAP SHOWING DATA FROM OBSERVATIONS BY UNITED STATES WEATHER BUREAU AT 8 A.M. ON A WINTER'S DAY.

## LXVI. — THE WEATHER MAP

**Materials.** **Colored pencils.**

**Purpose.** *To understand the meaning of the symbols on a weather map; to appreciate the method of constructing such a map; and to study the relations between air pressure and weather, under cyclonic and anticyclonic conditions.*

**Making a weather map.** On the map of the United States (Fig. 34) are data from observations made by the United States Weather Bureau at 8 A.M. on a winter's day. At this hour the observers at each of the places marked on the map made observations of their thermometers, barometers, etc., and telegraphed the results to Washington. There a weather map was made to show the weather conditions over the entire country at that hour. The data that were telegraphed to Washington are printed on the map. You are to construct the weather map.

First draw the isothermal lines (using a red pencil) as directed on page 289. Next draw in the isobars, using a blue pencil. To do this, follow the same method as in drawing the isothermal lines, showing differences for each tenth of an inch by a separate isobar. Draw each of the isobars through places having the same barometric pressure; or on the proper side of those places where the pressure was not exactly a tenth of an inch. For instance, the isobar would be drawn through a place having 29.9 inches; but it must go to one side of a place having a reading of 29.93, or of a place having a reading of 29.89. Having completed the isobars, mark the word HIGH in the place where the lines inclose an area of high pressure; and mark the word LOW in the place where the lines inclose an area of low pressure.

With black pencil or ink, draw arrows to show the wind direction at each place, remembering that the letters N.W., N., etc., refer to the compass directions *from* which the winds blow. Place the point of the arrow on the end *toward* which the wind is blowing. Finally, color (with green pencil) the area where rain (*r*) or snow (*s*) are falling, making the snow area a heavier green than the rain. In this shading you can color in the area between places that have the same letters.

**Observation of the weather map.** Is it colder within the area of the high or of the low pressure? ______________________

______________________ In which of the two areas is there clear weather? ______________

______________________________ In which is there rain or snow? ______________________

____________________ In what part of the low-pressure area is rain falling? ______________

______________________________________________________________________________

__________________________________________________________________________ In what part

snow? ________________________________________________________________________

______________________________________________________________________________

_________ Using the scale of miles (printed on the map), measure the distance from east to west in which there is precipitation. ______________________ Measure the diameter of the area of precipitation along a north-south line. ______________________ Do the winds blow toward or away from the area of high pressure? ____________________________________________

Do they blow toward or away from the area of low pressure? ____________________________

______________________________________________________________________________

Interpretation of the weather map.

If winds blow from all sides toward a center, what must become of the air as it flows toward the center? ______________________________________________ If the relative humidity of the air is high, what must happen as it rises? ______________________________________

______________________________________________________________________________

______________________________________________________________________________

__________________________________________________ Apply this in explanation of the large area in which there is precipitation around the Low. ______________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

____________________________________________________ Where does the air obtain its vapor?

______________________________________________________________________________

What bearing has this on the fact that there is a larger area of precipitation on the east and south sides of the Low than on the north and west? ______________________________________

______________________________________________________________________________

______________________________________________________________________________

____________________________________________________ Why is it warmer on the south and east sides of the low-pressure area than on the north and west sides? ______________________

______________________________________________________________________________

______________________________________________________________________________

_________________________________________________________________ What bearing has this on the distribution of rain and snow in the area of precipitation? ________________________

______________________________________________________________________________

______________________________________________________________________________


*Scale of Statute Miles*

0 100 200 300 400 500

FIG. 35. — MAP SHOWING SAME DATA AS FIG. 34, BUT FOR FOLLOWING DAY.

--------------------------------------------------------------------------------------------

------------------------------------------------------------

If the winds blow outward from an area of high pressure, where does the air come from?

---------------------------------------------- Is air above the earth warmer or colder than that at the surface? (Text-book, p. 240.) -------------------------- How does this help to explain the temperature within the high-pressure area? ------------------------------------

--------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------

-------------------------------------------------------- Air settling from above the surface grows warmer; does it then cause clear or cloudy weather? ------------------------------------

----------------- Apply this in explanation of the conditions in the high-pressure area.

--------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------

--------------------------------------------------------------------------------------------

**Making a weather map for the next day.**

Figure 35 gives data for the weather map at 8 A.M. on the next day to the one just studied, these data having been obtained by the Weather Bureau observers, as before. On this map draw in (as on the previous map) the isotherms, isobars, and wind directions; color in the areas of rain and snow; and mark the areas of high and low pressure.

**Comparison of the two maps.**

In which direction has the low-pressure area moved in the twenty-four hours? ---------------

---------------------------------- In which direction has the high-pressure area moved?

------------------------------------------------ Mark their courses on Figure 35 by means of a colored line (brown). Do the winds still blow in the same way (as in Fig. 34) around the high and low pressure areas? -------------- Is there still the same relation between precipitation and barometric pressure? ------------------------------------------------ Between areas of pressure and temperature? ----------------------------------------------

------------------------------------------------.

By examining and comparing the two maps, state what changes have occurred at Chicago in (*a*) barometric pressure ------------------------------------------------------------

--------------------------------------------------------------------------------------------

----------------------------- ; (*b*) wind directions ----------------------------------------------

; (*c*) precipitation

; (*d*) temperature.

Make the same comparison for New York.

For your own home.

## LXVII. — STUDY OF THE WEATHER MAP

**Materials.** **For Each Student. — A copy of a weather map (any date will do).**

**For General Class Use. — Thermometer. Barometer. The daily weather map.**

(The daily weather map will be sent on application from the nearest Weather Bureau station, and it should be posted in a prominent place.)

**Purpose.** *To study the local weather changes and note their relation to high and low pressure areas.*

**The information on a weather map.** Each student is given a copy of a weather map.

What do the dotted lines represent? ______________________________

Where is the coldest weather? ______________________________

______________________________ The warmest? ______________________________

______________________________ What do the continuous lines represent? ______________________________ What do the figures at their ends (29.9, 30.2, etc.) indicate? ______________________________ Where is the pressure highest? ______________________________

______________ Where lowest? ______________________________

______________________________ What word is printed in the anticyclonic area or areas? ______________ In the cyclonic? ______________ What do the arrows represent? ______________________________ In what directions are the winds blowing in the low-pressure areas? ______________________________

______________________________

______________________________

______________________________ In the regions of high pressure? ______________________________

______________________________

______________________________

______________________________ What symbols are used to represent clear, partly clear, and cloudy sky? ______________________________

______________________________

In which of the areas, the cyclonic or the anticyclonic, is there the greatest extent of clear weather?

Of cloudy weather?

In what manner are rain and snow recorded?

When, with reference to the high and low pressure areas, is there most rain in a given region?

When (if at all) is there snow?

What symbol is used for thunder storms?

Do you find any on your map? If so, where do they occur with reference to the pressure conditions?

What data are printed in the columns in the right-hand half of the bottom of the map?

From these columns find out and record the temperature, wind velocity, and precipitation at Washington, D.C.

At the Weather Bureau station nearest your own home.

Read the printed matter on the left-hand part of the bottom half of the weather map. What kinds of information are given there? ________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

**Study of the local weather.**

Observe and make a record of the local weather conditions of this day, as follows: The temperature. ____________ The barometric pressure. ____________ Direction of wind. ____________ Velocity of wind (light, strong, etc.) ____________ Condition of sky (clear, cloudy, or partly cloudy). ____________ Precipitation (rain, snow, or clear). ____________ Is the barometer low or high? ____________ What relation, if any, do you see between the pressure and the cloudiness or precipitation? ________________________________

________________________________________________________________

________________________________________________________________

____________ Is the temperature higher or lower than yesterday? ____________ Is there any noticeable relation between this change in temperature and the pressure and wind direction? ________________________________

________________________________________________________________

________________________________________________________________

____________ Make a prediction, as best you can, for to-morrow, — do you expect it to be warmer or colder? ____________ Rainier or clearer? ________________________________

Examine the weather map for to-day. Where is the nearest area of high pressure?

________________________________________________________________

Of low pressure? ________________________________

________________________________________________________________

____________ In what direction, in each case, from your home? ____________

In which direction will they probably move by to-morrow?

Using the scale of miles printed on the map, and by comparison with yesterday's map, find out how far each has moved since yesterday.

How many miles an hour is that?

How far, then, may you expect them to move by to-morrow?

What change in your local weather should these movements of high and low pressure areas bring about by to-morrow?

Now examine the predictions made by the Weather Bureau and compare them with your own predictions.

To-morrow examine the weather map to see how nearly the predictions were verified. Record the results.

(This work may be profitably repeated for several successive days, or until the pupil thoroughly understands the significance of the weather map and is able, from a rapid study of it, to see what it shows as to actual conditions, and the basis upon which predictions are made. Even after the formal laboratory work on weather maps is completed, the student should examine the daily weather map, and make his own predictions and, by examining the instruments in the school, note how temperature, wind, and precipitation are related to pressure.)

**General conclusions.** From the study of the weather maps, and from the observation of local weather conditions, answer the following questions: In which direction do most of the high and low pressure areas move? ______________________________

______________________________

______________ At about what rate? ______________

When a Low passes over your home, what changes come (*a*) in pressure, ______________

______________ (*b*) in temperature, ______________

(*c*) in wind direction, ______________ (*d*) in wind velocity,

______________ (*e*) in cloudiness, ______________

(*f*) in precipitation? ______________ Answer the same questions for the High-pressure areas. ______________

______________ (*a*) ______________

(*b*) ______________ (*c*) ______________

(*d*) ______________ (*e*) ______________

(*f*) ______________

About how much of the United States do the low-pressure areas cover at any one time?

______________________________

Give their greatest length and width in miles. ______________

______________________________

______________ About how far apart are the Lows and Highs?

______________________________

About how often does a Low pass over your home? ______________

______________________________

______________ Are they always equally well developed?

______________ When is there most rain, when the low-pressure area is well developed or only moderately developed? ______________________________________________

______________________________________________________________________

During what conditions of pressure does your coldest weather come? ______________________

______________________________________________________________________

______________________________________________________________ Your warmest?

______________________________________________________________________

Explain this in each case. ______________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

Cyclonic storms develop in the belt of prevailing west winds. If these winds should blow every day in your locality, would they be dry or rainy winds? ______________________

Cold or warm in winter? ______________________________ Cool or hot in summer?

________________________________ Of what importance, therefore (assuming that you live in the west-wind belt), are the cyclonic storms to your locality: (*a*) because of their influence on temperature? ______________________________________________

______________________________________________________________________

______________________________________________________________________

______________________ (*b*) because of their influence on rainfall? ______________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________

## LXVIII.—ISOTHERMAL CHARTS OF THE WORLD

**Materials.** **For Each Student.—Colored pencils.**

**Purpose.** *To study and interpret isothermal charts of the world for summer, winter, and the year.*

**Study of isothermal chart of the world for July.** Figure 36 is an isothermal chart of the world for the month of July. With your colored pencils give different colors to the following parts: (*a*) all over 80°; (*b*) from 70° to 80°; (*c*) 50° to 70°; (*d*) 30° to 50°; (*e*) all below 30°.

In what general direction do most of the isotherms extend? ______________________________

____________________ In which hemisphere (northern or southern) do they follow this direction

with greatest regularity? ______________________________________________________ Explain the difference between the isotherms of the northern and southern hemispheres in this respect.

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

Does the belt of greatest heat coincide with the equator? ______________ Draw a line on the map to show the approximate position of the belt of greatest heat. This will be the *heat equator* for July. Mark it so on the map. Where does it lie with reference to the equator?

______________________________________________ Are the warmest areas in the northern or

southern hemisphere? ______________________________________________ Why? ____________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

Are they over the water or over the land? ____________________________________________ Why?

________________________________________________________________________________

________________________________________________________________________________

**Study of isothermal chart of the world for January.** Figure 37 is an isothermal chart of the world for the month of January. Color this map as follows: (*a*) all over 80°; (*b*) from 70° to 80°; (*c*) from 50° to 70°; (*d*) from 30° to 50°; (*e*) from 0° to 30°; (*f*) from $-30°$ to 0°; (*g*) all below $-30°$.

Give two reasons why it is so much colder in the northern than in the southern hemisphere in January. ______________________________

______________________________

______________________________

______________________________

Where are the lowest temperatures? ______________________________

______________________________

______________________________ Why there? ______________________________

______________________________

______________________________

______________________________

______________________________ Where is it warmest? ______________

______________________________

______________________________ Why there? ________

______________________________

______________________________

Draw in the heat equator on this map. Explain its position. ______________

______________________________

______________________________

______________________________

______________________________ Fill out this sentence:

The heat equator moves ______________ in summer, and ______________ in winter.

**Comparison of January and July charts.**

In which hemisphere is there the greatest difference (called *range*) in temperature between January and July? ______________________________ Account for this difference.

______________________________

______________________________

______________________________

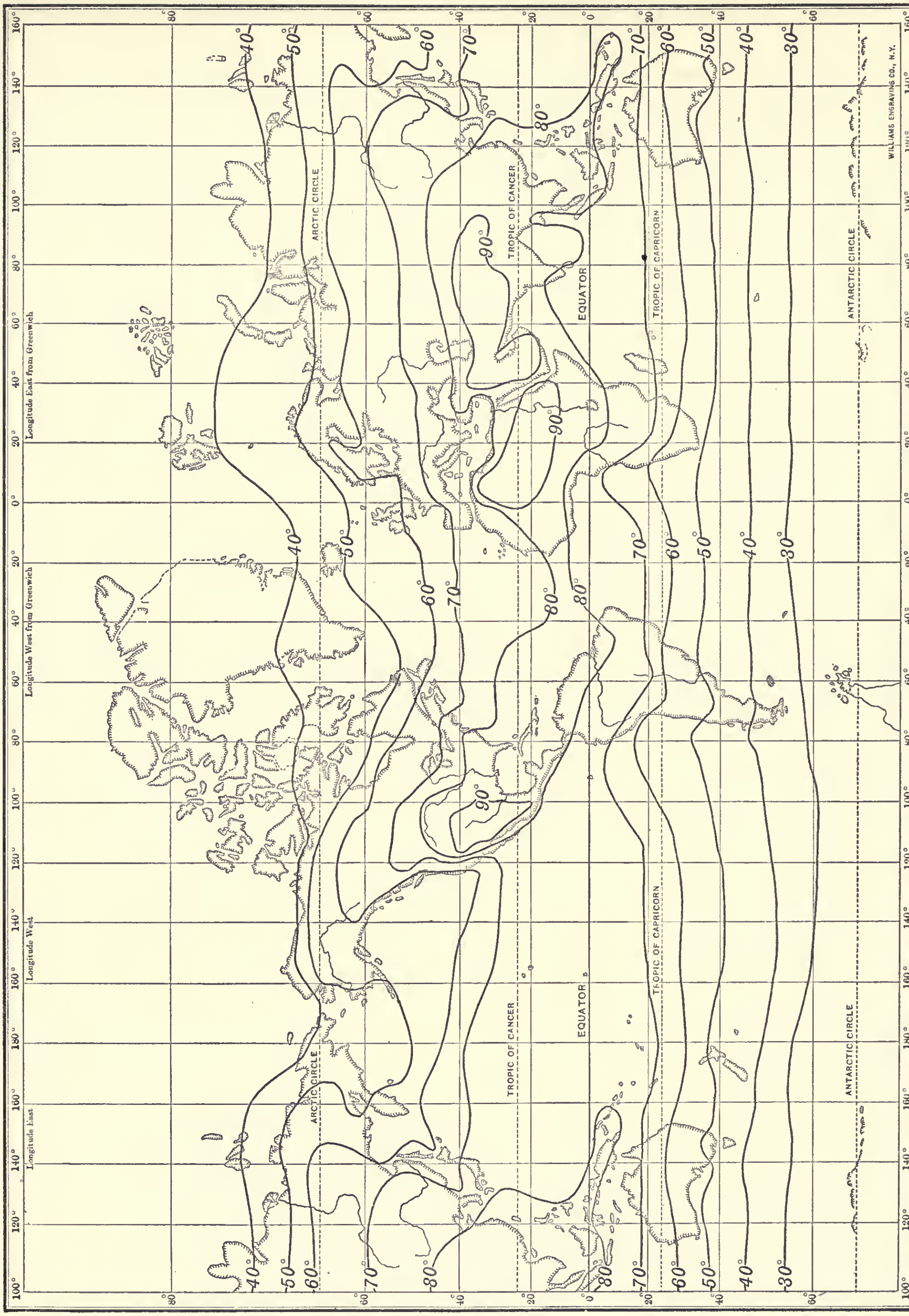


FIG. 36. — AN ISOTHERMAL CHART OF THE WORLD FOR JULY.

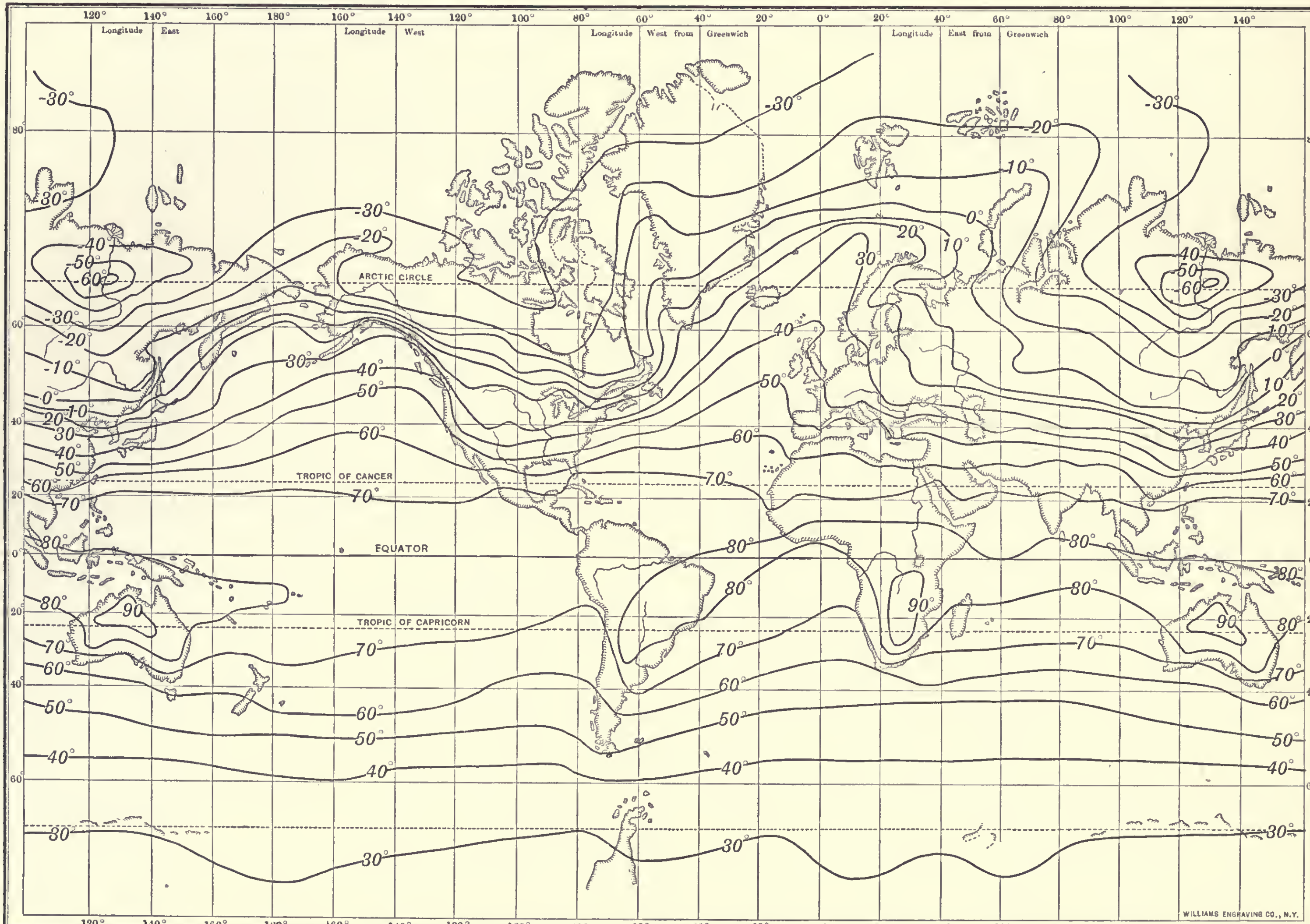


FIG. 37. — ISOTHERMAL CHART OF THE WORLD FOR JANUARY.

How much is the difference, or range, on the Arctic Circle, on the meridian 120° E. Long. ?

............................................ About how much on the Antarctic Circle on

the same longitude ? ............................................

On each of the charts, follow the 40° parallel of north latitude, and in the table set down the temperatures for the places mentioned. In the lower columns insert the temperature range.

| MONTH | CENTRAL JAPAN | CENTRAL ASIA LONG. 80° E. | SPAIN | CENTRAL ATLANTIC LONG. 40° W. | EAST COAST U.S. | CENTRAL U.S. LONG. 100° W. | WEST COAST U.S. | CENTRAL PACIFIC LONG. 160° W. |
|---|---|---|---|---|---|---|---|---|
| July | | | | | | | | |
| January | | | | | | | | |
| Range | | | | | | | | |

Account for the high temperature range in Central Asia. ............................................

............................................

............................................

............................................

In central United States. ............................................

............................................

............................................

Contrast these temperature ranges with those in the central Atlantic and Pacific oceans.

............................................

............................................

............................................

............................................

How do the temperature ranges on the Atlantic and Pacific coasts of the United States

compare ? ............................................

............................................

............................................

How do those of the Atlantic and Pacific coasts of Eurasia compare?

Which of the coasts of the United States most nearly resembles eastern Eurasia in temperature range? Western Eurasia?

How is this to be explained?

**Study of isothermal chart of the world for the year.**

Figure 38 is an annual isothermal chart of the world; that is, it represents the average temperature for the *entire* year. Color this map as follows: (*a*) all over 80°; (*b*) 70° to 80°; (*c*) 50 to 70°; (*d*) 30° to 50°; (*e*) 0° to 30°; (*f*) below 0°.

On the map draw in the heat equator. Why should it lie north of the equator?

Trace the isotherm for 50° in the southern hemisphere. What is its direction?

Examining the ocean current map (Fig. 22), state why this isotherm bends northward on the west coast of South America.

Trace the isotherm for 50° in the northern hemisphere. How does it compare in direction with the 50° isotherm in the southern hemisphere?

Account for its northward bend in crossing the Atlantic.

Account for its southward bend

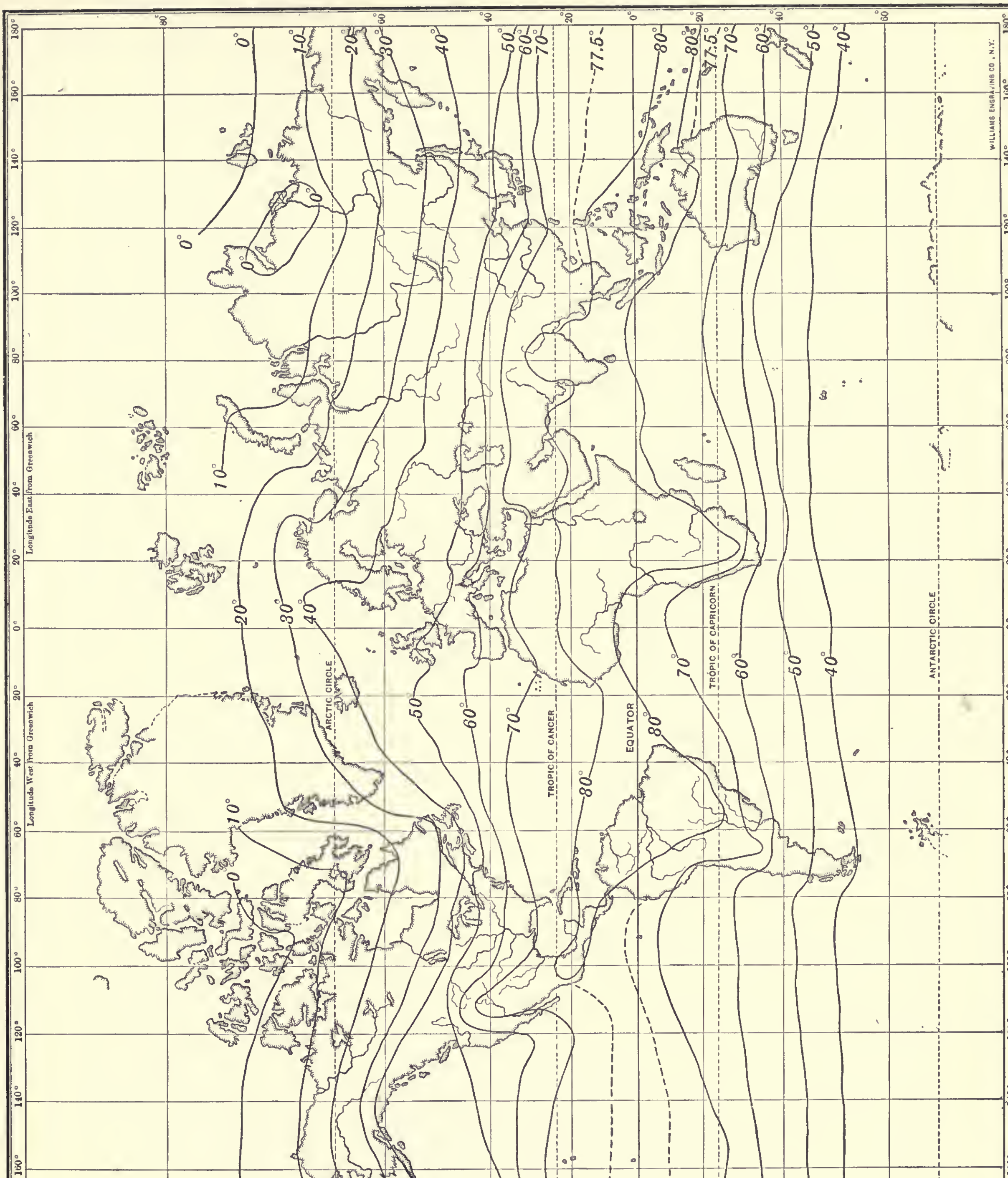


FIG. 38. — ANNUAL ISOTHERMAL CHART OF THE WORLD.

on the east coast of North America. ____________________

____________________

____________________ Account for its northward bend in central North America. ____________________

____________________

____________________

Explain the northward bend of isotherms on the west coasts of South America and Africa. ____________________

____________________

____________________

The northward bend of isotherms between Iceland and Scandinavia. ____________________

____________________

____________________ What countries of western Europe are crossed by the 50° isotherm? ____________________

____________________

____________________ Where does this isotherm cross eastern United States? ____________________

____________________

How do the latitudes of these two places compare? ____________________

____________________

____________________ What country of Europe is in the same latitude as the part of eastern United States that the 50° isotherm crosses? ____________________

____________________ What isotherm crosses that part of Europe? ____________________ How do you account for these differences in temperature between eastern United States and western Europe? ____________________

____________________

____________________

____________________

How do the isotherms of western Europe compare with those of western United States in the same latitude? ----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

**Comparative study of isothermal charts.**

By examining the isothermal charts for July, January, and the year, state, in general terms and a few sentences, what the summer, winter, and annual temperatures are in the Torrid Zone. ----------------------------------------

----------------------------------------

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----------------------------------------

----------------------------------------

In the North Temperate Zone. ----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

In the South Temperate Zone. ----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

In the North Frigid Zone. ----------------------------------------

----------------------------------------

----------------------------------------

----------------------------------------

In the South Frigid Zone. ----------------------------------------

----------------------------------------

Do the boundaries of these zones seem to be regular, and to follow exactly the circles of latitude? Where, for instance, do torrid conditions in summer extend into the temperate zone?

Where do Arctic conditions extend in winter into the temperate zone?

Which isotherm on the July chart passes nearest your home?

Name other places in the northern hemisphere on the same isotherm.

In the southern hemisphere.

Answer the same questions for the January chart.

For the chart of the year.

## LXIX. — WINDS OF THE EARTH

**Materials.** **Colored pencils.**

**Purpose.** *To study the relation between atmospheric pressure and the planetary winds; to note the distribution of these winds; and to consider their effects.*

**Study of an isobaric chart of the world.** Figure 39 is an isobaric chart of the world for the year. That is, it shows the average atmospheric pressure for all parts of the earth. With the colored pencils color in: (*a*) all the area which has a pressure of over 30.00 inches; (*b*) the areas with pressure between 29.90 and 30.00 inches; (*c*) the areas between 29.80 and 29.90 inches; (*d*) the areas of less than 29.80 inches.

How does the pressure in the equatorial belt compare with the regions immediately to the north and south of it? ______________________________ Which way, then, should the winds blow in these regions? ______________________________

______________________________ Make a drawing to show the circulation of the air between the Tropic of Cancer and the Tropic of Capricorn. In this drawing you should show four movements of the air: (1) along the surface; (2) a rising; (3) a flowing away at the higher level; and (4) a settling of the air.

How does this drawing resemble that of the circulation of air in a room heated by a stove (Fig. 31)? ____________________

____________________

____________________

The *trade winds* blow steadily toward the equator from both the south and the north. By means of arrows indicate these winds on the isobaric chart (Fig. 39). To what part of the air current in your drawing (Fig. 31) are these winds equivalent? ____________________

____________________ The *belt of calms* is the area where the warm air is rising. Indicate its position on both the map and the drawing. The *anti-trades* are the winds flowing away from the equator, high above the earth's surface. Indicate these on your drawing. The *horse latitudes* are where the air is settling. Mark the position of the two belts of horse latitudes on both the map and the drawing. In what direction would you expect the winds to blow on the poleward side of the belts of high pressure? ____________________ These are the two belts of *prevailing westerlies.*

On Figure 39 find several places where the pressure is over 30.10 inches. Which way must the air be moving in these areas of high pressure? ____________________ Find two areas in the northern hemisphere where the pressure is as low as 29.70 inches. How must the winds be blowing in these regions? ____________________

**The wind belts.** Figure 40 shows the prevailing winds of the earth in the month of January. You will note that the wind directions in the regular wind belts do not exactly agree with those you have drawn in Figure 39. The winds have been deflected from true north and south directions by the influence of the earth's rotation. On Figure 40 place the following names in their proper places: northern prevailing westerlies; southern prevailing westerlies; belt of northern horse latitudes; belt of southern horse latitudes; belt of northeast trades; belt of southeast trades; belt of calms, or doldrums. In which two belts is the air settling? ____________________

____________________

____________________. In which belt is the air rising? ____________________

____________________

On page 314 you learned that the heat equator moves north in summer and south in winter. Since the trade winds represent cooler air flowing toward this heated belt, what change in their position must occur with the changes in season? ____________________

____________________

____________________

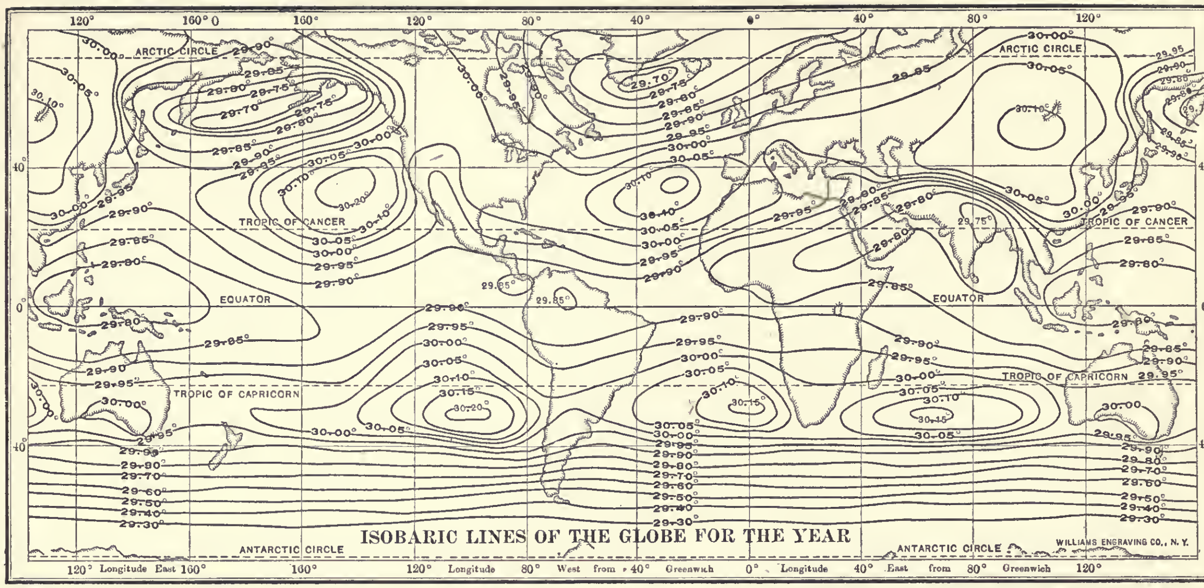
ISOBARIC LINES OF THE GLOBE FOR THE YEAR
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
120° Longitude East 160°
160°
120° Longitude 80° West from 40° Greenwich
0° Longitude 40° East from 80° Greenwich 120°
WILLIAMS ENGRAVING CO., N. Y.

FIG. 39.

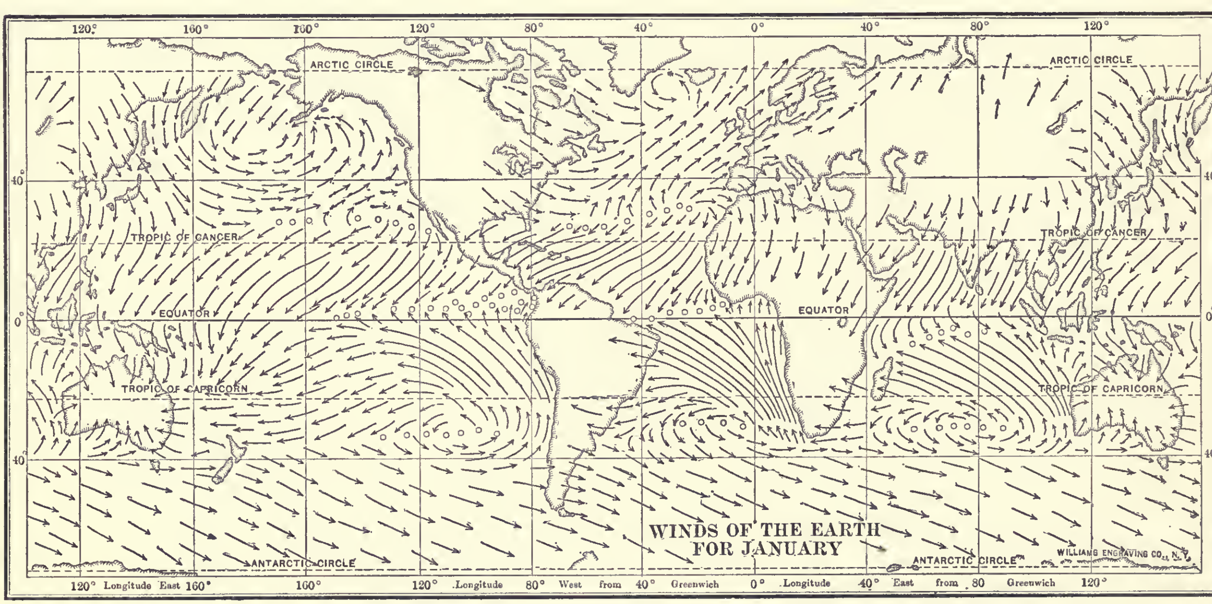
WINDS OF THE EARTH FOR JANUARY
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
120° Longitude East 160°
160°
120° Longitude 80° West from 40° Greenwich
0° Longitude 40° East from 80 Greenwich 120°
WILLIAMS ENGRAVING CO., N. Y.

FIG. 40.

**Deflection of winds by the earth's rotation.** Currents of air and water on the earth are turned by the influence of the earth's rotation *toward the right* in the northern hemisphere, and *toward the left* in the southern hemisphere (Text-book, p. 258); that is, if you stand so that a current strikes your back, the current will be deflected towards your right in the northern hemisphere. Apply this to explain why the trade winds blow from the northeast and southeast, instead of from due north and south.

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What compass direction does the influence of rotation cause winds to have in the northern hemisphere when blowing from the south? ----------------------------------------

What direction in the southern hemisphere when blowing from the north? ---------------

------------------------------ How does this apply in explaining the direction of the prevailing westerlies? ------------------------------------------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

**Winds in areas of low and high pressure.** What is the direction of the winds in Eurasia: (*a*) in the northern part? --------------------------------------- ; (*b*) in the eastern part? ------------------------------------; (*c*) in the southern part? ------------------------------------------ Why should winter winds blow outward from the cold interior of a continent? -----------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

---------------------------------------------------- On the map of the isobars (Fig. 39) there are three areas of high pressure over the ocean in the southern horse latitude belt, and two in the northern horse latitude belt. Locate these five areas on Figure 40 and state how the winds blow in such areas. ------------------------------------------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

---------------------------- Locate the two areas of low pressure (in the North Atlantic and North Pacific) and state how the winds blow there. ------------------------------------

**Winds on water and land.**

Is the temperature of water more or less uniform than that of land? Differences in temperature give rise to differences in air pressure, and these to winds. Where, then, should the winds have a more regular direction, on land or on water? Examine the map to see if the trade winds have a more constant direction on land or on water. How about the belt of northern prevailing westerlies? The southern belt of prevailing westerlies? Why do the latter winds blow more regularly than those of the northern hemisphere?

**Windward and leeward coasts.**

On which coasts (east-facing or west-facing) do the trade winds blow from the sea? On which from the land? On which coasts do the prevailing westerlies blow from the sea? What effect must this have on the temperature of the land that they reach? On which coasts do the westerlies blow from the land? What effect must this have on the temperature of these coasts in summer?

In winter?

Which of the coasts (east or west) in the westerly belts must therefore have the more equable climate?

## LXX. — RAINFALL OF THE UNITED STATES

**Materials.** **For Each Student. — Colored pencils. Ruler.**

**For General Class Use. — A rain gauge.** (A tinsmith can make a fairly satisfactory rain gauge. See Text-book, p. 424.)

**Purpose.** *To study the distribution of rainfall in the United States, and to discover the reasons for the differences in amount.*

**Observing amount of rainfall.** For two weeks keep a record of the amount of rainfall, measuring it after each rain. Measure the depth of the water in the tube with a ruler, remembering that this depth is ten times the actual rainfall. Why is it advisable to so construct the rain guage that the rain from an area of ten square inches is collected instead of from only one square inch?

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What is meant when one says "an inch of rain has fallen"? ------------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

-------------------------------------------------- Is an inch of rain a light or heavy rainfall? ---------------------------------------- What is meant by saying "the annual rainfall is 100 inches"? ------------------------------------------

--------------------------------------------------------------------------------

--------------------------------------------------------------------------------

------------------------------------ What is the rainfall of your own region (Fig. 41)?

---------------------------------------- Has a region with 100 inches of rainfall a dry or a rainy climate? --------------------------------------------------------

Fill the cylinder of the rain gauge with snow to a depth of ten inches (but do not pack it tightly), and allow the snow to melt. How much water gathers in the bottom of the cylinder? ---------------------- What do you conclude therefore as to the amount of snow that represents an inch of rain? ----------------------------------------------

------------------------------------

**Rainfall of the United States.**

On the map of the United States (Fig. 41) the lines indicate the amount of rainfall in inches. Color in (with green pencil) the areas with a rainfall of over 60 inches. In what two parts of the country is there the heaviest rainfall? ______________________________

______________________________________________________________________

______________________________________________________________________

____________________________________________________ By examining the map showing the winds of the earth (Fig. 40) account for these two areas of heavy precipitation.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________ Color in (with blue pencil) the areas with a rainfall of between 50 and 60 inches. A rainfall of 50 inches or more is heavier rainfall than is common. What parts of our country have such a condition of rainfall? ______________________________

______________________________________________________________________

____________________________________________________________

Color in (with brown pencil) those sections with a rainfall of less than 10 inches. Such a rainfall is altogether too little for agriculture, and deserts commonly exist where there is such light rainfall. What states and parts of states, therefore, have a desert condition of rainfall? ______________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

In which of the wind belts are these desert regions located? ______________________________

______________________________________________________________________

______________________________________________________________________

____________________________________________________________ What explanation can you give for these desert conditions? ______________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________


FIG. 41. — MAP OF UNITED STATES SHOWING ANNUAL RAINFALL IN INCHES.

Color in (with yellow pencil) the sections with a rainfall of from 10 to 20 inches. In general, a rainfall of less than 20 inches is too little for agriculture; and the country included in the belt with rainfall between 10 and 20 inches may be called the arid country. What states, or parts of states, are included in this arid belt? ........................................

....................................................................................................

....................................................................................................

....................................................................................................

.................................................................................. What explanation can you offer for the fact that the arid lands are mainly in the interior of the country? ..................

....................................................................................................

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....................................................................................................

....................................................................................................

.................................................................................. In the arid belt you will note on the map that there are small areas with a heavier rainfall. What is the explanation of these? ........................................................................

....................................................................................................

....................................................................................................

...................... Why is there such an abrupt change from heavy rainfall in western Washington to light rainfall in eastern Washington? ........................................

....................................................................................................

....................................................................................................

.................................................................................. Fill out the following sentence: On the windward side of mountains the rainfall is ........................; on the leeward side the rainfall is ........................................................................

....................................................................................................

Why is evaporation greater in the southern than in the northern part of the arid belt?

....................................................................................................

....................................................................................................

How does this help to explain the fact that in some parts of the north, as in eastern Washington and eastern Dakota, there is extensive wheat raising, although the rainfall is less than 20 inches? ______________________________

Color in (with red pencil, in parallel ruled lines) the areas with a rainfall of from 20 to 30 inches. What states are partly included in this belt? ______________________________

______________________________ Account for the fact that in Texas the western portion of this area has too little rainfall for agriculture. ______________________________

______________________________ Color in (with blue ruling) the areas with a rainfall between 30 and 40 inches; and the areas (with green ruling) between 40 and 50 inches. About what proportion of the United States has rainfall enough for agriculture (20 inches or over)? ______________________________ In what parts of the country is this condition general? ______________________________

______________________________ What means are adopted to supply moisture for agriculture in the arid and desert sections? ______________________________

State how the rainfall varies from the mouth of the Mississippi to northern Minnesota.

______________________________

From Virginia to southern California. ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________ From the coast of Washington to the coast of Maine.

______________________________

______________________________

______________________________

______________________________

Following along several lines from the coast to the interior, what do you discover as to the general change in amount of rainfall? ______________________________ Fill out the following sentence: In general, the amount of rainfall ______________ from coast to interior. Account for this fact. ______________________________

______________________________

______________________________

______________________________

______________________________

______________________________

## LXXI. — RAINFALL OF THE EARTH

**Materials** **For Each Student. — Colored pencils.**

**Purpose.** *To study and understand the cause for the distribution of rainfall over the earth.*

**Belts of heavy rainfall.** Figure 42 is a blank map of the world with the rainfall of the continents indicated by a series of lines. By reference to the Text-book (Fig. 444), secure data for filling in, with the green pencil, the areas which have heavy rainfall. In which zone do most of these areas lie?

By examining the map of winds of the earth (Fig. 40), determine in which of the wind belts the largest areas of heavy rainfall lie?

How do you account for this fact?

There is heavy rainfall also in some small sections of the temperate zones. On which coasts of the continents are these located? In what wind belts?

Account for these areas of heavy rainfall.

**Desert areas.** Color in (with brown pencil) the areas which have desert conditions. In which zones are these located?

Why should there be arid conditions in the horse latitude belts?

Which coasts (east or west facing) have desert conditions in the trade wind belts? ______________ Why is there heavy rainfall on the opposite coasts in these belts? ____________________

Fill in this sentence: Windward coasts in the trade wind belts have ______________ rainfall; leeward coasts have ______________ rainfall. Cuba and Porto Rico lie in the path of the northeast trade winds. What must be the condition of rainfall on the northeast side? ______________ On the southwest side? ______________

Account for the arid regions in the west wind belts of North America and South America. ____________________

Which continents have the largest area of desert land? ____________________ How do you account for this in each case? ____________________

**Regions of light rainfall.**

Color in (with yellow pencil) the regions of light rainfall. What portions of the northern continents are included? ____________________ Why should there be less rainfall in the cold north than in the warm south? ____________________

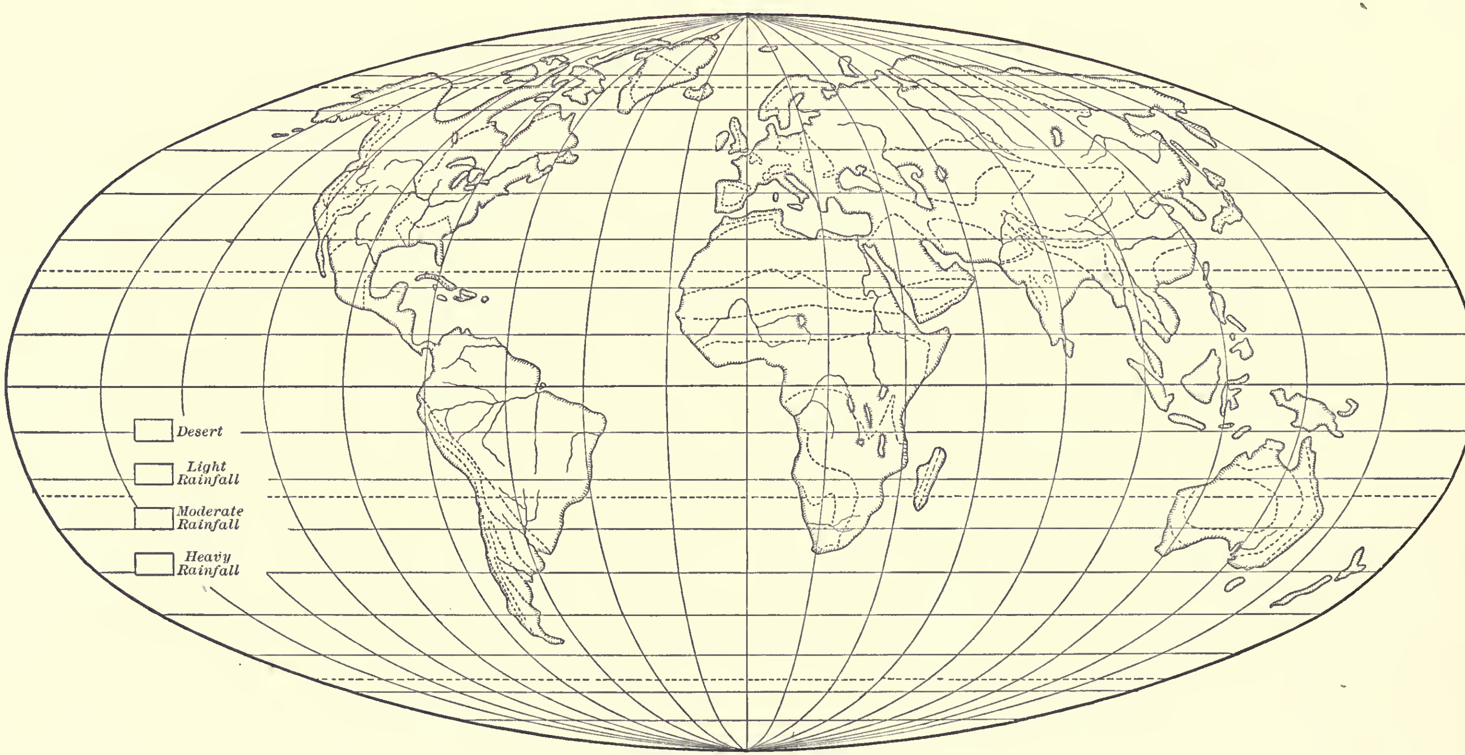


FIG. 42. — RAINFALL MAP OF THE WORLD.

Why are regions of light rainfall extensive in the continent interiors?

Would these regions of light rainfall be better suited for grazing or for agriculture?

Why would this be less true in the cool north?

As the belt of calms shifts northward in summer and southward in winter, how would the rainfall vary with the season in that part of Africa that lies south of the Desert of Sahara? (Text-book, p. 283.)

How would the rainfall vary with the season in the southern part of Africa?

At what season would agriculture be possible in each of these two regions?

Why are these regions (the savannas) grass lands and not forest-covered lands?

**Regions of moderate rainfall.** Color in the remainder of the map (with blue pencil) to show the areas of moderate rainfall. What parts of North America are included?

Of Eurasia?

Europe, eastern United States, and southeastern Asia are the most densely settled parts of the earth. What is the condition of rainfall in each of these sections?

Why are desert countries sparsely settled?

Why are the warm regions of heavy rainfall also unsuited to dense settlement?

What reasons can you give for the fact that the most densely settled parts of the earth are mainly located in those parts of the temperate zone in which there is moderate rainfall?

**Comparison of North America with other continents.**

How does North America compare with other continents in amount of desert?

In extent of country having heavy rainfall?

In extent of country having moderate rainfall?

In which of these respects is North America favored as compared with other continents?

Write a brief statement as to the advantages that North America has as to rainfall and temperature as compared with (*a*) Eurasia; (*b*) South America; (*c*) Africa; (*d*) Australia.

## LXXII. — LIFE ZONES ON THE EARTH

**Purpose.** *To understand the relation between climate and the plant zones of the earth; and the chief reasons for the distribution of animal life on the earth.*

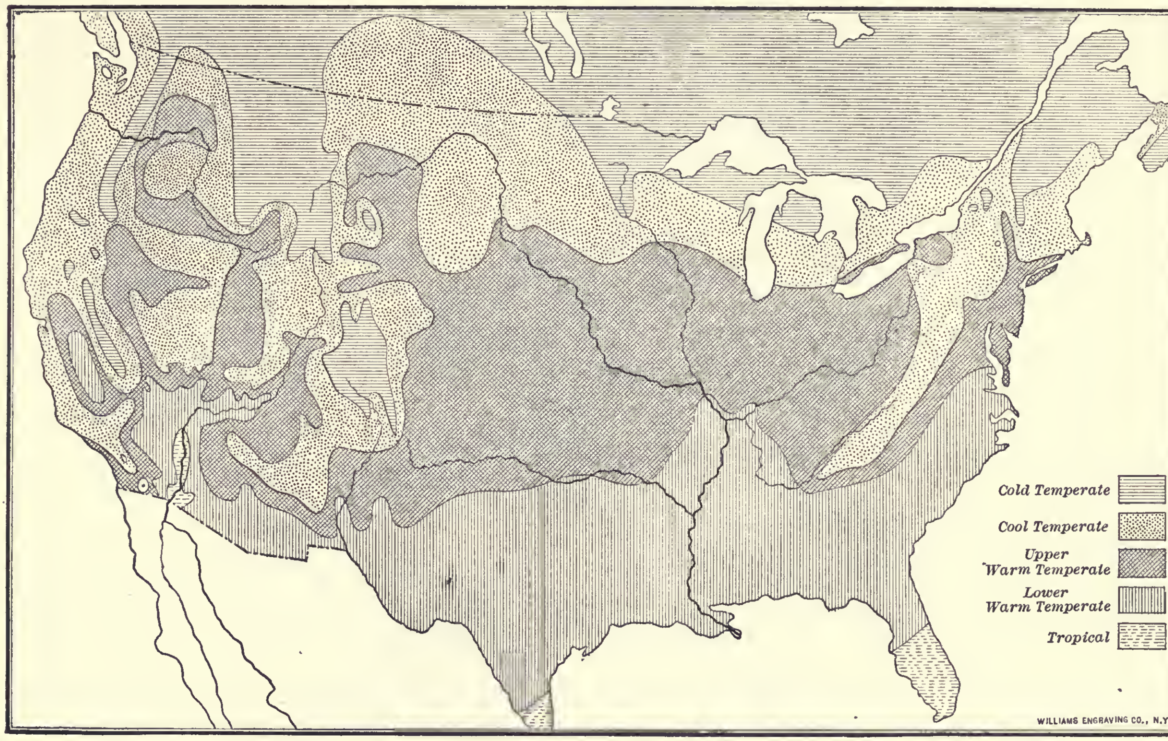


FIG. 43. — ZONES OF PLANT LIFE IN THE UNITED STATES AS INFLUENCED BY TEMPERATURE.

**Plant zones of the United States.** Figure 43 shows the different zones of plant life in the United States as influenced by the temperature. In what three sections of the country are tropical conditions found?

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Explain the presence of tropical conditions in each of these three places. ---

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FIG. 44. — MAP OF DISTRIBUTION OF PLANT LIFE OVER THE WORLD.

Where are cold north-temperate conditions found? ..........................................

..........................................................................................

Explain the presence of cold climate plants so far to the south in western United States.

..........................................................................................

In what portions of the country are warm temperate plants found? ..........................

..........................................................................................

Cool temperate plants? ....................................................................

..........................................................................................

..........................................................................................

**Distribution of plants in the world.**

Trace the northern limit of trees (Fig. 44). Why cannot trees grow north of this line? .............................................. To the north of the tree line is the tundra region. What countries of Eurasia and North America are partly within the tundra belt?

..........................................................................................

Why is there so little tundra in the southern hemisphere? .................................

..........................................................................................

Trace the northern and southern limits of palms. What kind of climate do they require? .............................................. What countries of Europe and North America are included in the belt of palms? ...........................................

..........................................................................................

..........................................................................................

.................................. Why does the limit of palms extend so much farther north in Europe than in America? ..................................................

..........................................................................................

..........................................................................................

What two continents are almost wholly in the belt of palm growth? .........................

..........................................................................................

In which continents are the tropical forests most extensive? ..............................

..........................................................................................

In what wind belts (Fig. 40)?

What are the temperature and rainfall conditions in the tropical forest belt?

Make a list of the tropical trees of which you know the names.

Through what countries does the belt of most extensive forest in the temperate zone extend?

What are the temperature and rainfall conditions there?

Make a list of some trees that grow in the cool temperate forest.

In which, the temperate or tropical forest belt, does vegetation grow most luxuriantly?

Through which of these forest belts would it be more difficult for an explorer to pass?

Why should so much forest be left in the more northerly countries, while it has been stripped off in the regions immediately to the south?

Explain the long, narrow strips of forest in the belt south of the northern forests.

In what zones are the principal agricultural belts located? ____________________

____________________________________________________________

____________________________________________ What leading countries in the northern hemisphere are included? ________________________________

____________________________________________________________

____________________________________________________________

______________________________ What countries in the southern hemisphere?

____________________________________________________________

What are the rainfall conditions in these belts? ______________________

____________________________________________________________

____________________________________________________________

__________________________________ If the land were not needed for agriculture, would forests grow in these belts? _____________ Trace the northern limit of grain. What countries of the northern hemisphere are partly to the north of this line?

____________________________________________________________

What countries of the southern hemisphere extend beyond the limit of grain growth?

____________________________________________________________

In which hemisphere, northern or southern, is most agricultural land found in the temperate zone? ________________________________

Locate the chief deserts and tell in which part of each continent they are found.

____________________________________________________________

____________________________________________________________

____________________________________________________________

Which continent has most desert? ______________________________ Which continent least? ______________________________ How does North America rank in amount of desert? ______________________________

____________________________________________________________

____________________ Why will forests not grow in deserts? ________________

________________________ In what zones are the largest deserts located? ________________

_____________________________________________________________________________ In what rainfall belts? ______________________________________________________________________________

__________

Where are the principal grazing lands located? ________________________________________

_______________________________________________________________________________________________

_______________________________________________________________________________________________

________________________________________________________ What are the rainfall conditions in such regions? ________________________________________________ Why are the savannas of the torrid zone arid in one season? ______________________________________________________________

_______________________________________________________________________________________________

_______________________________________________________________________________________________

__________________________________ Why are there great areas of grazing land in the interiors of continents? ___________________________________________________________________________

_______________________________________________________________________________________________

______________ Why do forests not grow in these regions? ______________________________

_______________________________________________________________________________________________

________________________________________________________________ Are the grazing lands sparsely or densely settled? _____________________________________________ How must they compare with the agricultural lands in respect to density of population? ______________________

_______________________________________________________________________________________________

_______________________________________________________________________ With the deserts?

_______________________________________________________________________________________________

Why are the tropical forests not densely settled? _________________________________________

_______________________________________________________________________________________________

_______________________________________________

**Distribution of animal life.** Figure 45 shows the three realms of animal life, and some of the main subdivisions. In each of these divisions the animals differ very much. From this map, what should you judge was the chief barrier to the spread of types of animals that live on the land? ______________

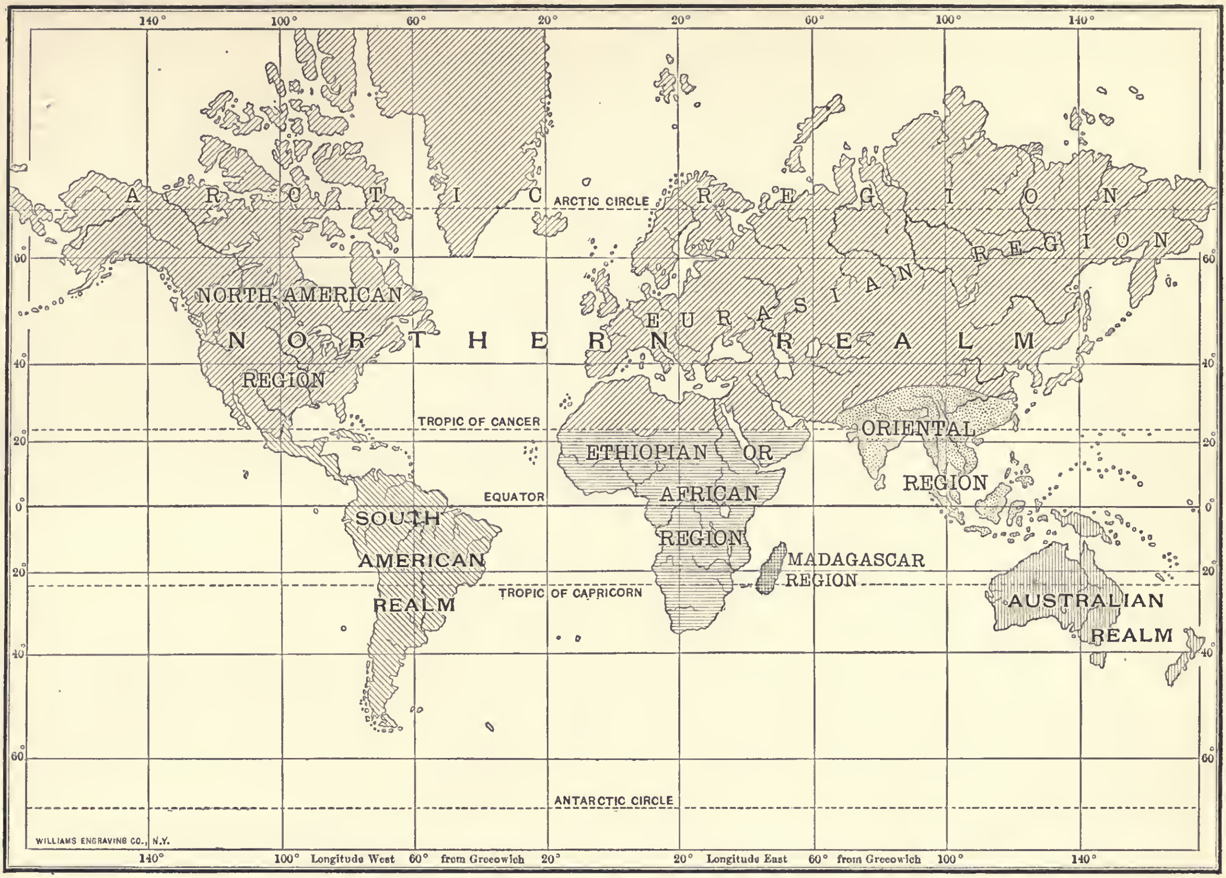


Fig. 45.—Map showing Three Realms of Animal Life and Main Subdivisions.

________________________________ Do deserts also serve as a barrier? _______________ Do mountain ranges? _______________ Do differences in temperature? _______________

Why should South American animals differ so greatly from those of Africa? ___________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________ What barrier would serve to check the spread of life to Australia? ___________________________

____________ What barrier partly cuts off the Oriental Region from the Northern Realm? ____________________________________________ What barrier tends to prevent the spread of animal life from the Northern Realm into the Ethiopian Region? ___________________________

__________________ Is such a barrier as effective as that between Africa and South America?

________________________ How may differences in climate help to account for the failure of animals of North and South America to migrate more freely? ______________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________

What one condition affecting animal life is practically the same throughout the extensive Northern Realm? ______________________________________________________________________

__________________________________________________________________________________________

____________________ How can you explain the fact that the animal life throughout this great realm is so nearly alike? ______________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

____________________________ What would be the effect of former greater elevations partly or wholly closing up the water areas between the continents? ________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

______________________________________________________________ Australian animals are wholly different from those of southern Asia. What does this fact indicate as to the probability of former connection between these two lands? ______________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

_____________________________________________

## LXXIII. — MAGNETISM

**Materials.** **For Each Student. — Two small needles.**

**For General Class Use. — Several small bar magnets (preferably one for each student). One or more magnetic compasses.**

**Purpose.** *To study the properties of a magnet, the magnetism of the earth, and the use of a compass.*

**The attraction of a magnet.** Let each student take one of the magnets and place it near his needle. What happens? ______________ Place one end of the magnet near the needle point. Now place the other end near the needle point. Repeat this at the other end of the needle. What happens in each case? ______________

______________

______________

______________ Try the magnet on objects other than iron (such as glass, a penny, a nickel, a dime, etc.) What is the result? ______________

______________

______________ What can you say about the attraction of the magnet? ______________

______________

______________

______________ Complete this sentence: There is some force in the ______________ which draws the ______________ to it. Of what metal is the needle made? ______________ Does the magnet attract other iron objects (such as a knife, nails, etc.)? ______________

**Magnetizing a needle.** Rub one of the needles over the magnet several times. Place this needle near the other one. What happens? ______________

______________ Now place one end of the magnet near the *point* of the needle that you have rubbed on the magnet. What happens? ______________

Try the other end of the magnet. What happens? ______________

Go through the same procedure with the eye of the needle. What is the difference in the behavior of this needle as compared to the one that was not rubbed on the magnet? __________

________________________________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

The two ends of the magnet are called its *poles.* Since the needle is now a magnet, what may its two ends be called? __________________________ Like poles of a magnet repel each other; and unlike poles attract each other. From this principle determine the like poles in the magnet and the needle. Find which end of the magnet will repel the north end of the needle in the compass. ____________________________________________________________

**Suggestion for home work.**

Take the magnetized needle home. Cut off a thin slice from a small cork and thrust the needle through the thin edge and parallel to the flat surface. Place this in a dish of water and the cork will float the needle. Which way does the needle point. ____________________________________________ Change its position and note if it returns to the same position as before? __________________________ Repeat this experiment several times. If you could get the same result in all parts of the world, what useful purpose would such a floating needle serve? __________________________________________________________

________________________________________________________________________________

________________________________________________________________________________

**The compass.**

How can you prove that the needle of the compass is not an ordinary piece of steel?

________________________________________________________________________________

Does it behave like the ordinary needle, or the magnetized needle, when the different poles of the magnet are brought up to it? ______________________________________________

________________________________________________________________________________

**Earth's magnetism.**

__________________________ What does this prove? __________________________________

________________________________________________________________________________

In what directions do the two ends of the needle of the compass point? ______________

________________________________ What makes the needle always come to rest in that position?

________________________________________________________________________________

On a large globe or a map of North America find Boothia Land where the north magnetic pole is situated. What is its location with reference to the north pole of the earth? ____________

______________________ In which of your previous experiments have you determined the true north-south line? ________________________________________ Does the compass needle point toward the north pole or the north magnetic pole? ______________________ ________________ What is the meaning of "true north"? ______________________ ____________________________________________________________________ ____________________________________________________________________ ____________________________________________________ Of "magnetic north"? ____________________________________________________________________ ____________________________________________________________________

With the compass find how many degrees difference there is between true and magnetic north in your locality. ______________________________________

**Isogonic map.**

Figure 560 in the Text-book is an Isogonic Map. What does it illustrate? __________ ____________________________________________________________________ ____________________________________________________________________ ________________________________________________________________ Find the isogonic line that runs nearest your home and draw it on the map (Fig. 46). How much is the declination? ______________________________________ Is it east or west declination? __________________ Knowing the declination, what correction to a compass reading would you have to make to get true north? ______________________________________ ____________________________________ Draw on the map the isogonic line that runs nearest New York City. What is the amount and direction of the declination there? ______________________________________ Do the same for Columbia, S.C. _________ ______________________________ For Augusta, Me. ______________________________ __________ For San Francisco. ______________________________________ In what part of the United States is there greatest east declination? ______________________________ Greatest west declination? ______________________________________

**Use of the compass.**

Of what use is the compass? ______________________________________________ ____________________________________________________________________ ____________________________________________________________________


FIG. 46. — BLANK CHART FOR DRAWING ISOGONIC LINES.

________________________. Why is it more useful to sailors than to any other class of men? ______________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

What is the significance of the fact that the use of the compass was discovered just before the time of Columbus? ______________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

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